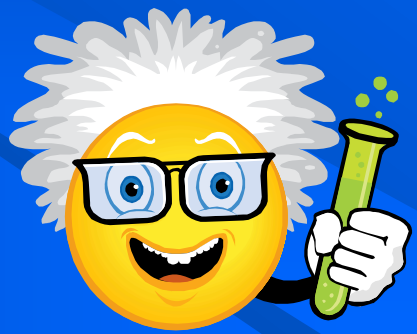
PPA and Binder Modification

John D'Angelo
Office of Pavement Technology

What is the Effect of PPA on binder properties?

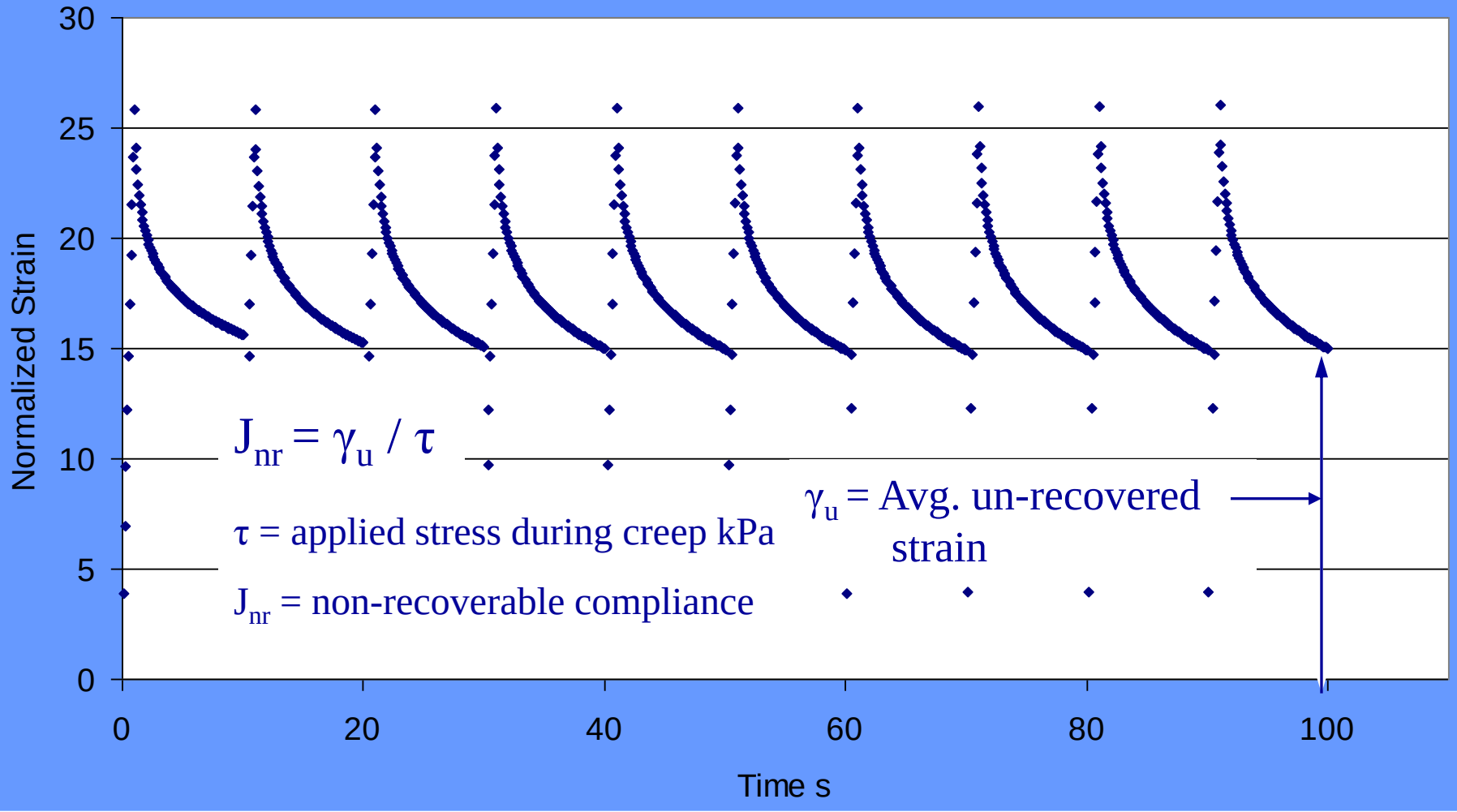
- How does PPA react with polymers?
- What is the affect of different crude sources?
- How does Hydrated Lime affect the interaction of the PPA and binder and polymer modification?



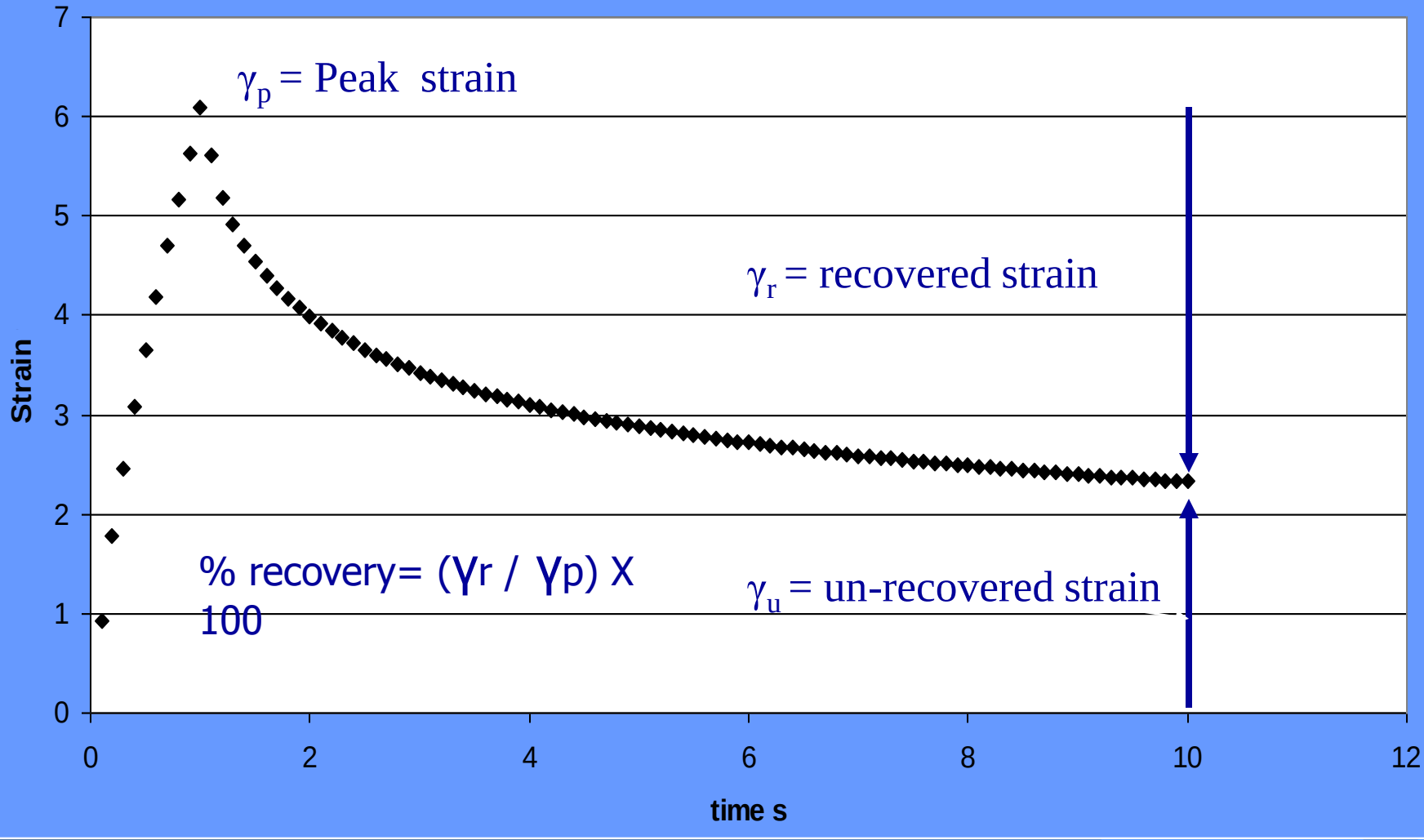
Evaluation Procedure

- AASHTO M320 Table 1
- AASHTO M320 Table 3
  - New High Temperature Grading System using MSCR
- % Recovery MSCR Test
- Elastic Recovery Test

AASHTO M320 Table 3 Determination of J_{nr}



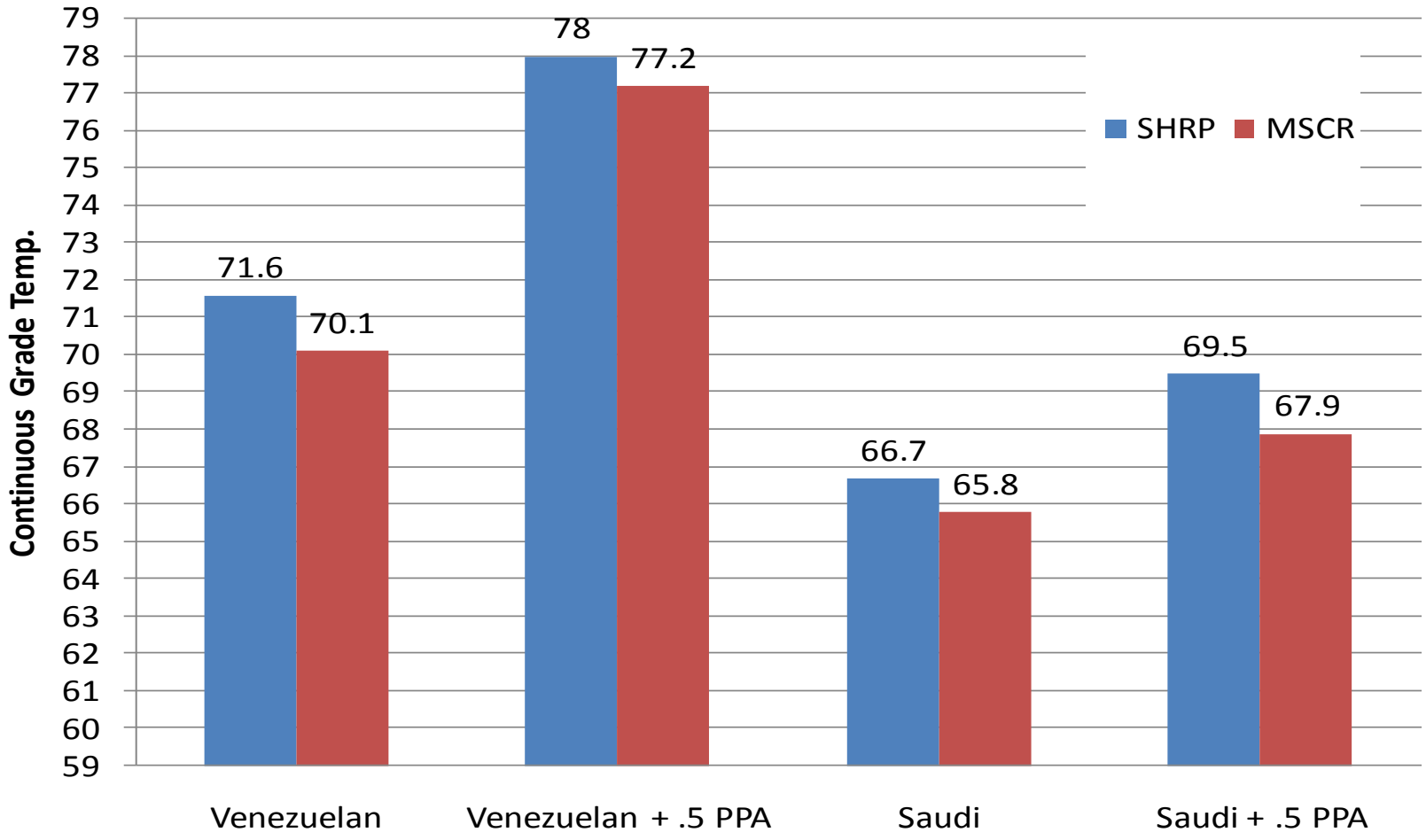
What is % Recovered Strain



Effect of PPA on High Temp Binder Grade

- Two Crude Sources
  - Venezuelan and Saudi Light
- One Level of PPA addition 0.5% by wt of Binder

Effect of PPA on High Temp Binder Grade



Effect of PPA on High Temp Binder Grade

- PPA Effected Different Crude Sources Differently.
  - .5% PPA Increased the grade temp of the Venezuelan 7˚C for both the Table 1 and 3.
  - .5% PPA Increased the grade temp of the Saudi Light 2 to 3˚C for both the Table 1 and 3.

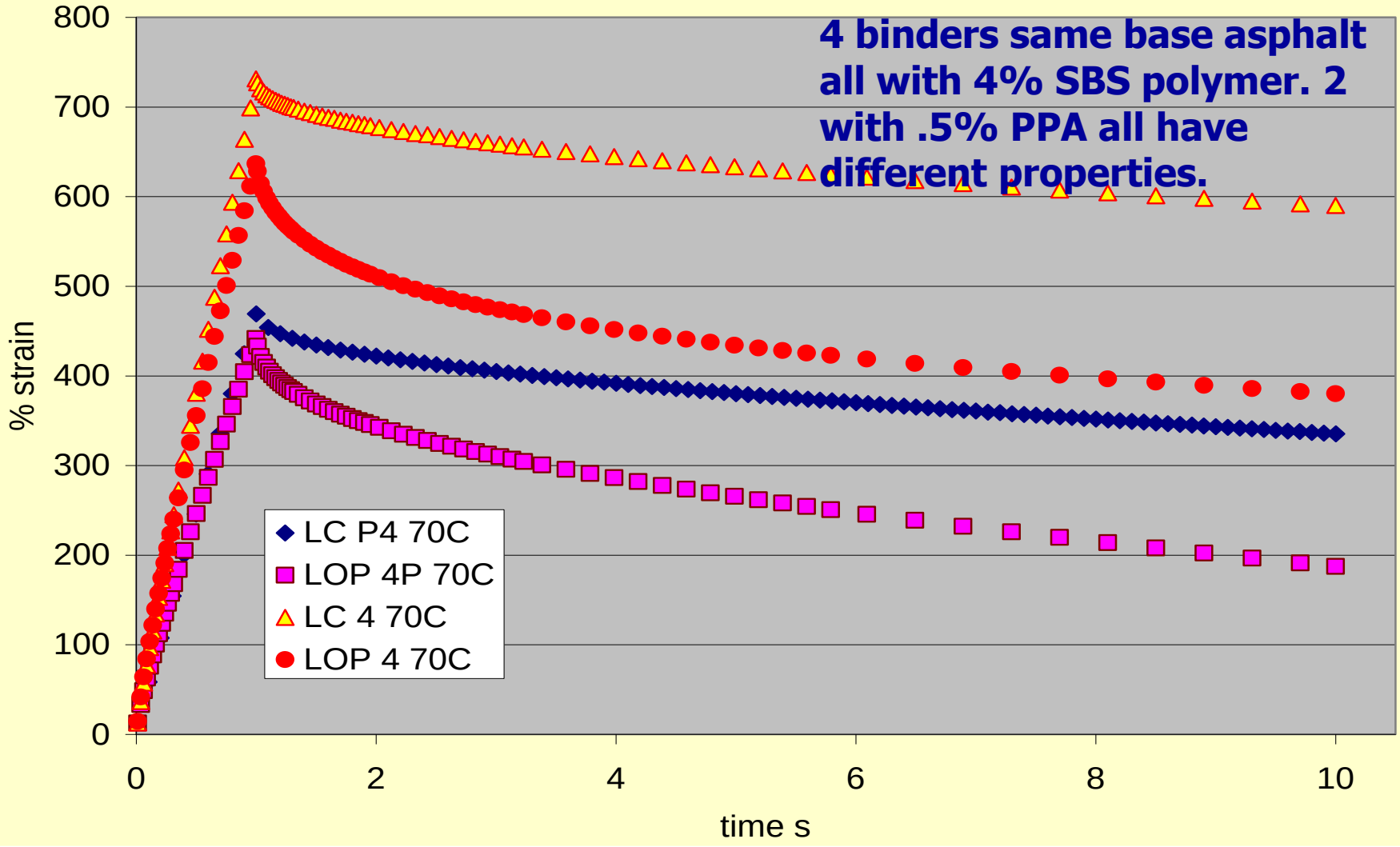
Effect of PPA on Blending of binders and polymers

- PG 64-22 Saudi Light Base asphalt
- 4 % SBS polymer
  - Radial
  - Linear
- 0.5% PPA
- 2 blending temperatures

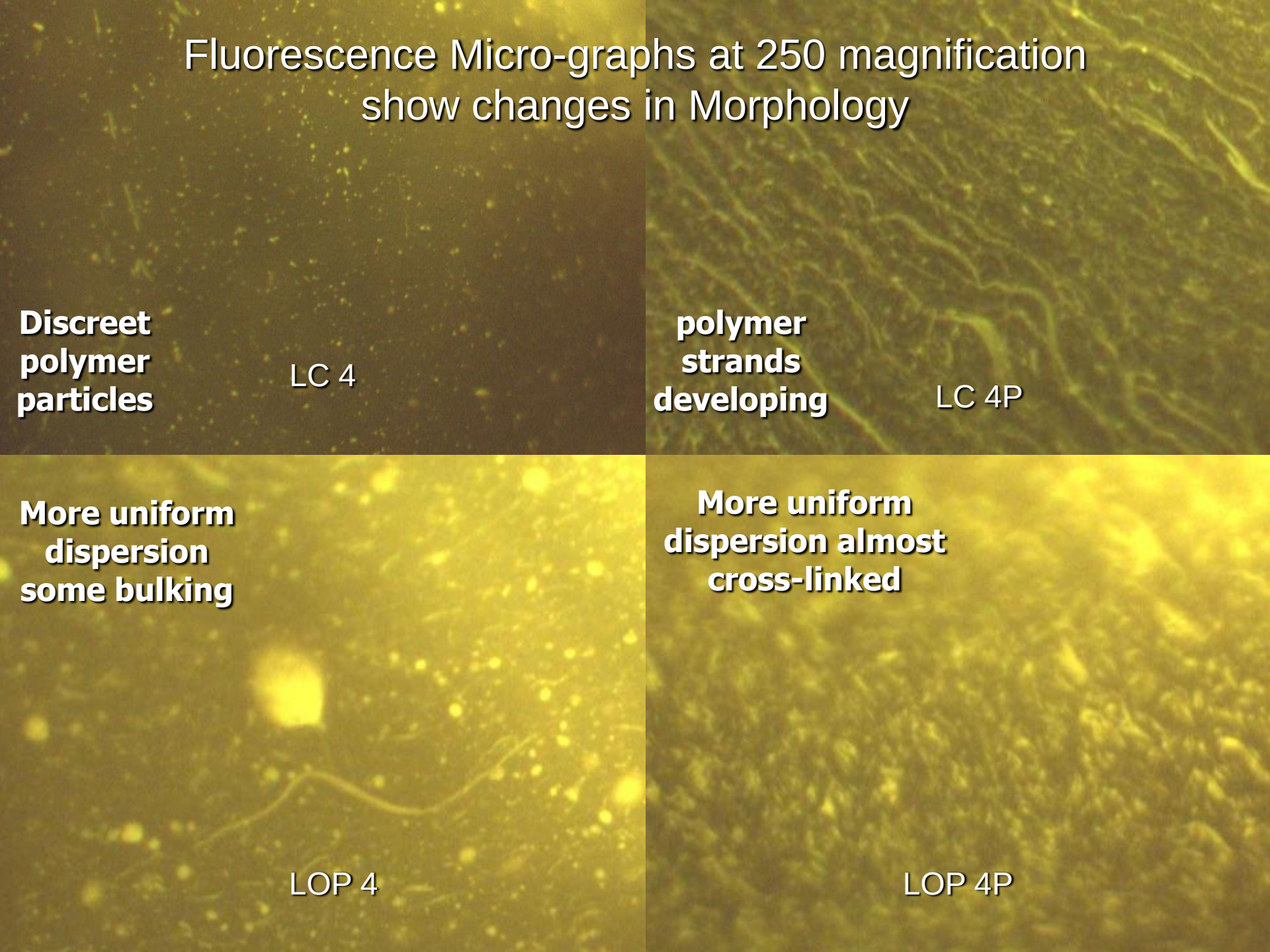
PPA Effects High temp and polymer network, MSCR more distinguishing

Sample ID	Continuous Grade	Polymer	Acid	Temp J_{nr} 3.2kPa = 1	ER	Temp C	% Recovery 3.2kPa
LC	66.7-24.1		0	56.4	5	64C	0
LC 4	75.7-22.3	4% SBS	0	65.1	73.8	70C	19.2
						76C	5.96
LC P4	81.2-22.2	4% SBS	0.50%	69.9	93.8	70C	28.4
						76C	20.55
LOP 4	76.6-25.2	4% SBS from Concentrate	0	69.1	86	70C	40.3
						76C	37.02
LOP 4P	81.6-24.5	4% SBS from Concentrate	0.50%	74.1	91.6	70C	52.05
						76C	42.52

Polymer network effects response and temperature effects.



Fluorescence Micro-graphs at 250 magnification show changes in Morphology



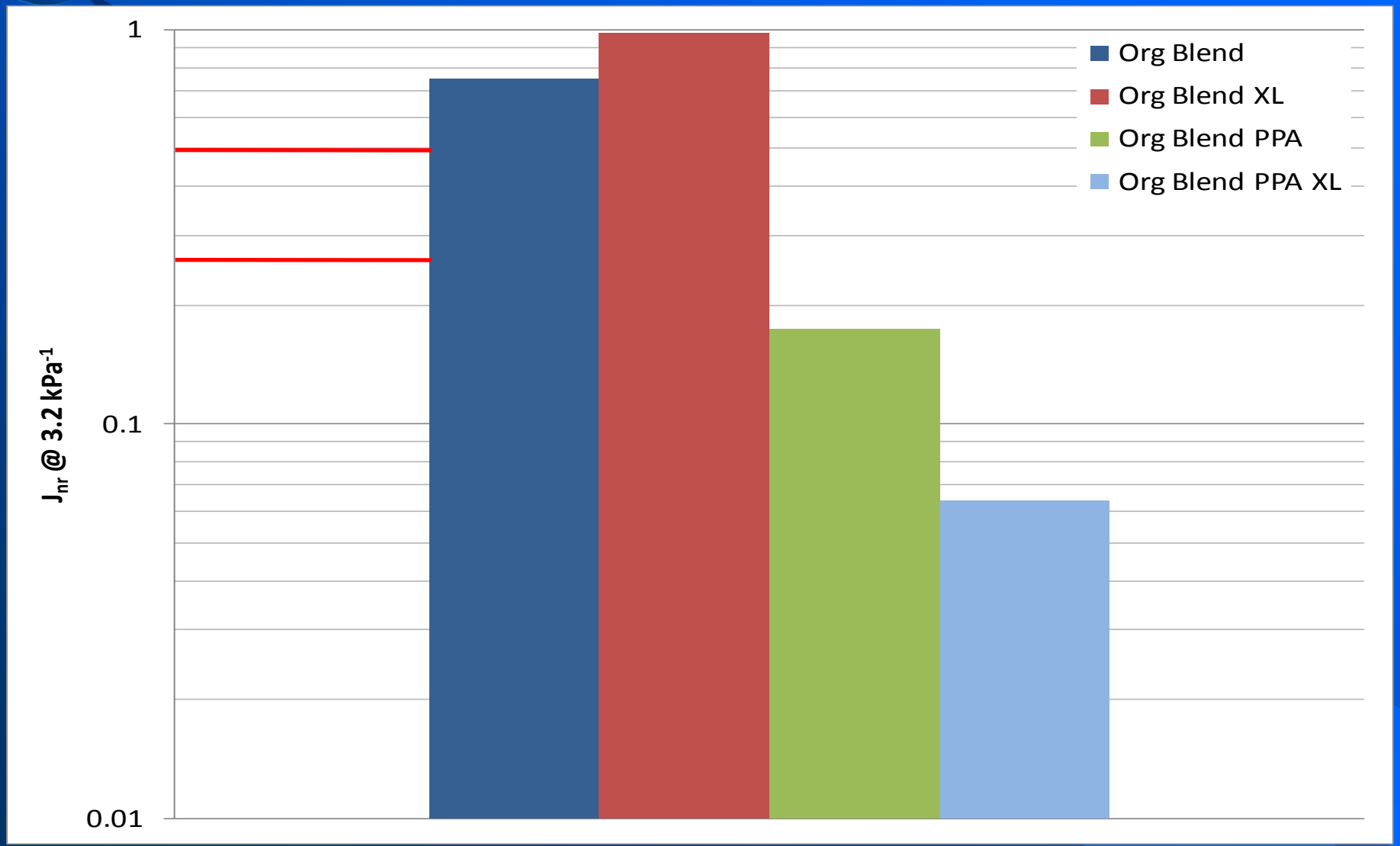
Effect of PPA on Blending of binders and polymers

- PPA improved both the High Temperature Grade and the polymer networking in the binders.
- G*/sinδ indicates a larger improvement than MSCR J_{nr}.
- MSCR % Recovery indicates improved cross-linking with PPA.

Effect of PPA on Binder SBS and Cross-linking

- Venezuelan 58-28 Base
  - Add 3% linear SBS
  - Add .06% Sulfur Cross-linker
  - Add .5% PPA

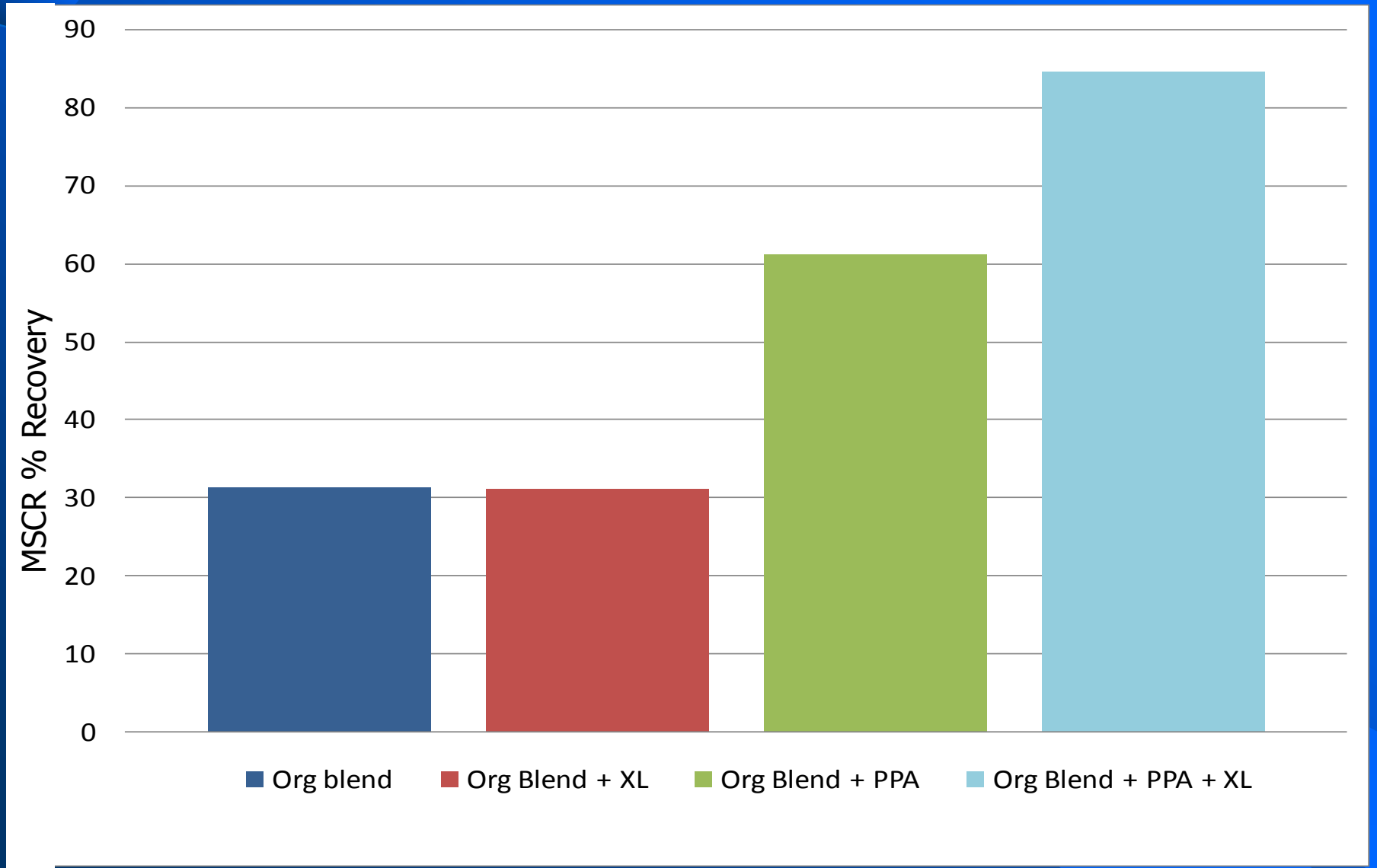
Change in MSCR with the addition of Cross-linker and PPA @ 64C



Change in MSCR with the addition of Cross-linker and PPA @ 64C

- The addition of 0.5% PPA to the Venezuelan 58-28 & 3% SBS changed the J_{nr} from 0.76 to 0.17 a 2 grade improvement
- The addition of 0.5% PPA to the Cross-linked SBS changed the J_{nr} from 0.99 to 0.06 a 3 grade improvement.

Change in MSCR % Recovery with the addition of Cross-linker and PPA @64C



Change in MSCR % Recovery with the addition of Cross-linker and PPA @64C

- The addition of 0.5% PPA to the Venezuelan 58-28 & 3% SBS changed the MSCR % Recovery from 30% to 60%
- The addition of 0.5% PPA to the Venezuelan 58-28 & 3% SBS + cross-linker changed the Changed the % Recovery from 30% to over 80%.
- PPA appears to improve the cross-linking of SBS in the binder.

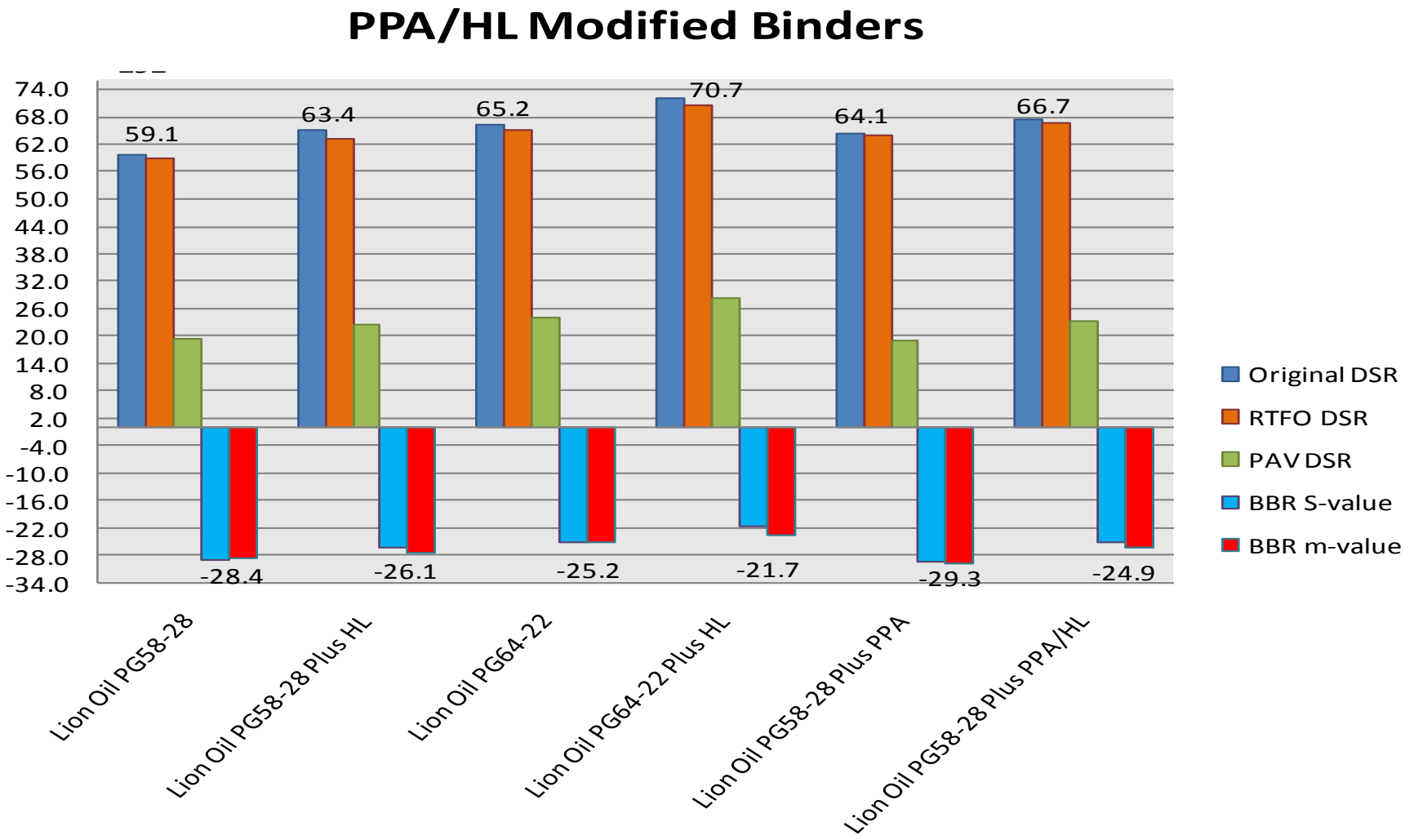
Effect of Hydrated Lime on PPA Modified Asphalt

- 64-22 Saudi Light blended with flux to produce a 58-28.
  - 1.2 % PPA was added to bring the binder back to a 64-22.
  - 20% Hydrated Lime was added to both the 58-28 and the 64-22.
  - 20% Hydrated Lime was added to the 58-28 + 1.2% PPA.
- Run complete PG grading and MSCR.

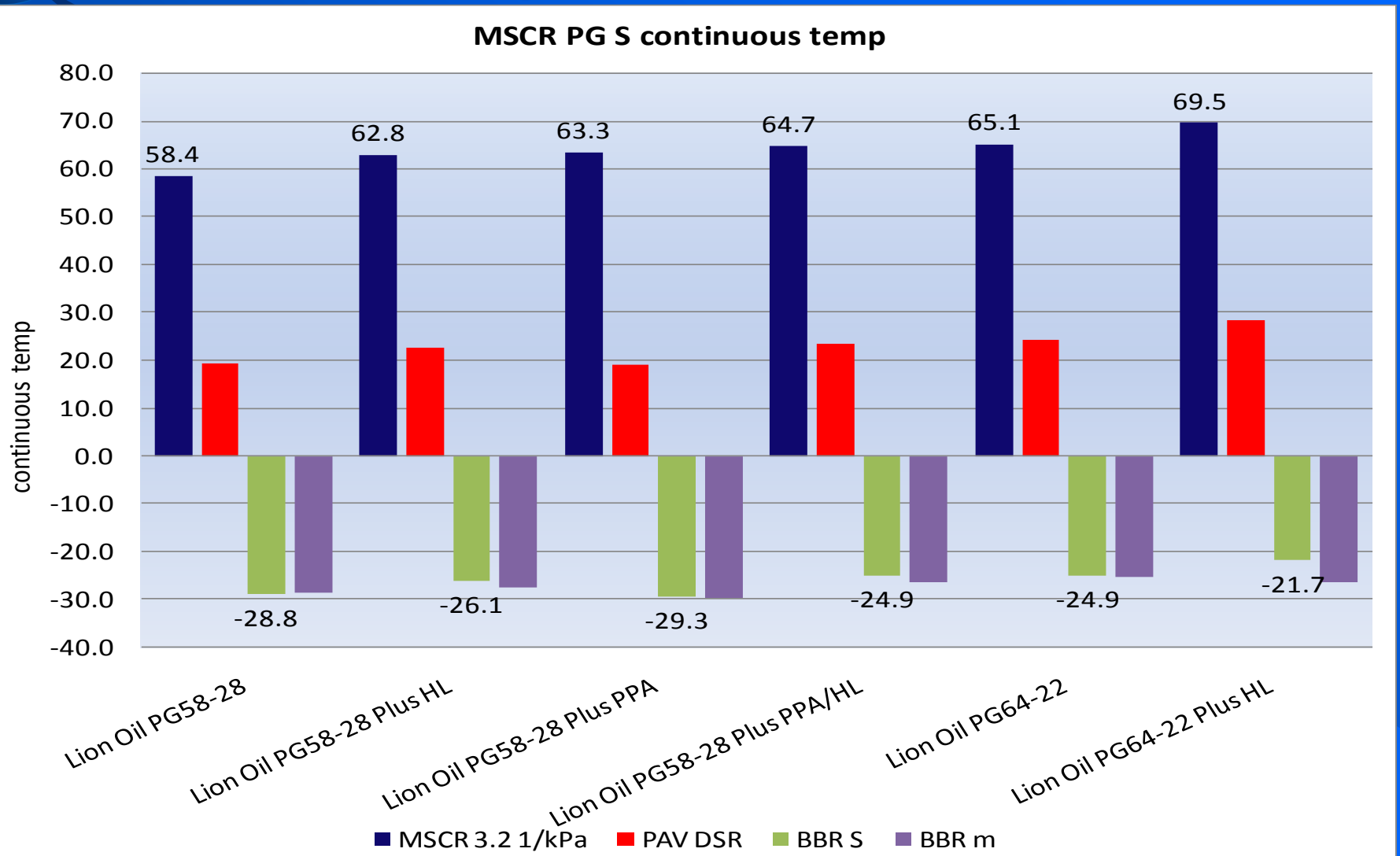
Effect of Hydrated Lime on PPA Modified Asphalt

- All testing was done with Hydrated Lime in the binder.
- Hydrated Lime has all material smaller than 75 microns, much less than the 250 spec T 315
- 20% Hydrated Lime by weight is approximately 7% by volume. Well below volumes that will affect validity of DSR measurements.

M320 grading for the different bends Effect of Hydrated Lime on PPA



MSCR PG-S M320 Table 3 grading Effect of Hydrated Lime on PPA



Effect of Hydrated Lime on PPA Modified Asphalt

- The addition of 1.2% PPA to the Saudi Light 58-28 increased the high temp grade of the binder by 5ºC for both $G^*/\sin\delta$ and J_{nr}.
- The Hydrated Lime increased the high temp. grade of the binder by 4ºC in both grading systems.
- If the Hydrated Lime increased the 64-22 by 4ºC it should increase the 58-28 with PPA by 4ºC also.

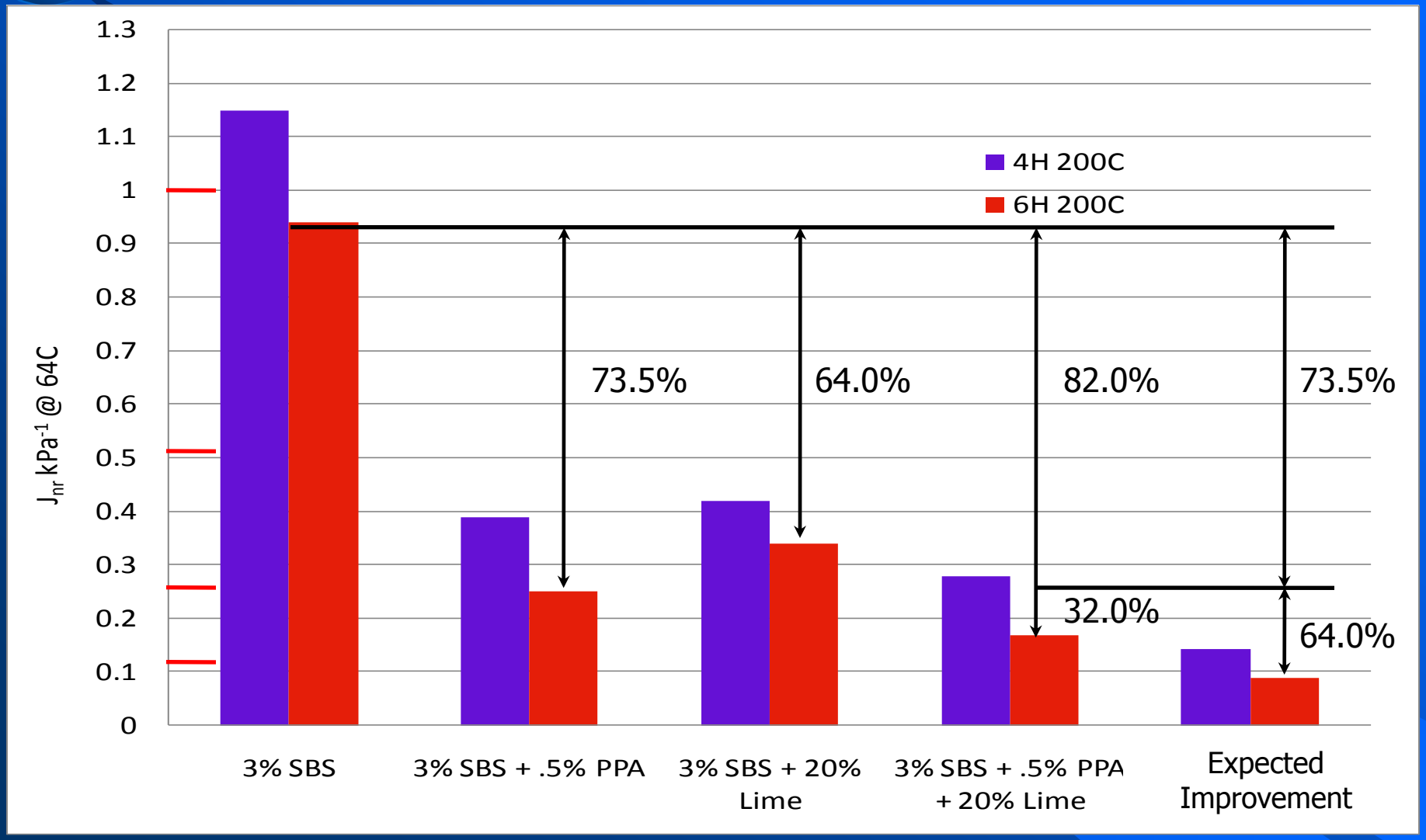
Effect of Hydrated Lime on PPA Modified Asphalt

- In this case the Hydrated Lime increased the high temp grade only 2.6ºC measured by G*/sinδ and only 1.5ºC measured by J_{nr}.
- For the Saudi Light it appears the Hydrated Lime is partially neutralizing the stiffening affect of the PPA.
- It is not a complete reversal by a one half to two thirds reversal based on the measuring system.

Effect of Hydrated Lime on PPA and SBS Modified Binder

- PG 58-28 base asphalt
  - Add 3% SBS
  - Add .5% PPA and 3% SBS
  - Add 20% Hydrated Lime to both the SBS binder and the SBS + PPA binder

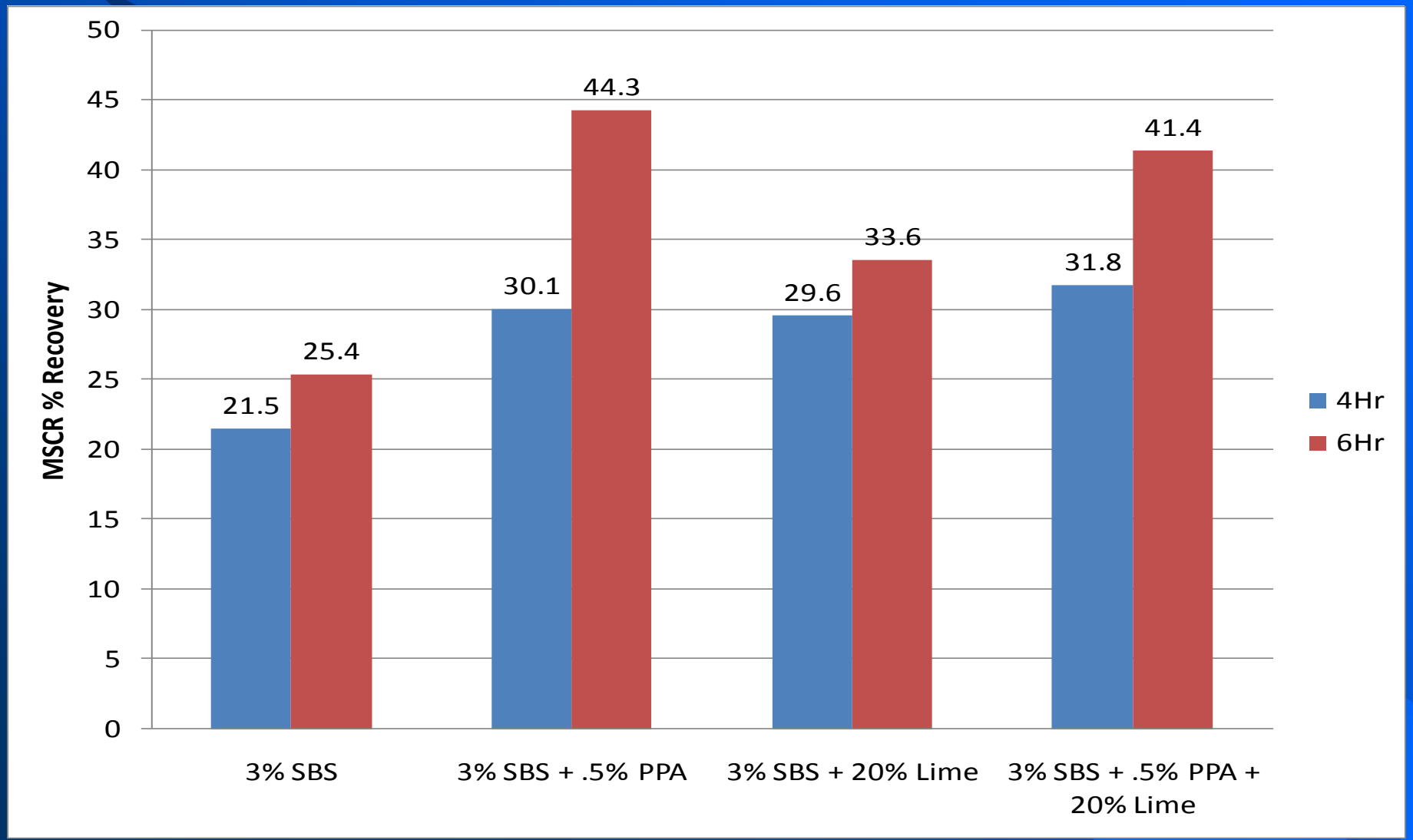
Effect of Hydrated Lime on PPA and SBS Modified Binder. MSCR J_{nr} @ 64C



Effect of Hydrated Lime on PPA and SBS Modified Binder. MSCR J_{nr} @ 64C

- .5% PPA added to the Venezuelan and SBS reduced the Jnr from .94 to .25 just at 2 full grades.
- 20% Hydrated Lime added to the Venezuelan and SBS reduced the Jnr from .94 to .34, 1 ½ grades or a V to an E.
- The PPA and Lime together reduced the Jnr from .94 to .17, 2 ½ grades not the expected 3 ½ grades.

Effect of Hydrated Lime on PPA and SBS Modified Binder. MSCR % Rec.



Effect of Hydrated Lime on PPA and SBS Modified Binder. MSCR % Rec.

- The .5% PPA had a significant effect on the MSCR % Recovery increasing it from 25% to 44%. This is likely due to increased stiffening and improved cross-linking
- The Hydrated Lime also increased the % Rec from 25% to 34%. This is likely due to increased stiffening.
- Together no real increase or decrease is seen over just the PPA. Once the polymer is cross-linked it does not appear the lime reduces the effect.

Conclusions

- PPA does increase the stiffness of asphalt binders in both the old Table 1 and new Table grading system.
  - The extent of the stiffening effect is crude source dependant
  - For high asphaltene Venezuelan .5% PPA will increase the stiffness one full grade.
  - For the lower asphaltene Saudi asphalt 1.2% PPA just makes one full grade stiffening.

Conclusions

- PPA improves the properties of SBS modified binders.
  - PPA appears to improve the cross-linking of the SBS in the binder improving % Recovery response and amplifying the stiffening effect of the PPA most likely through the improved cross-linking

Conclusions

- The addition of Hydrated Lime to PPA modified binders appears to reduce some of the stiffening effect of the PPA.
- The amount of reduction in stiffness varied from 30% to 50%.
- The Hydrated Lime does not appear to reduce the % Recovery of the binder. Once the cross-linking take effect the addition of Lime does not reduce it.

Conclusions

- PPA can be used to increase the stiffness of asphalt binders and improve cross-linking and elastic response of polymer modified binder.
- Extreme care must be taken when using PPA in a Mix where Hydrated Lime is used as a filler or anti-stripping agent.

Thank You

Questions