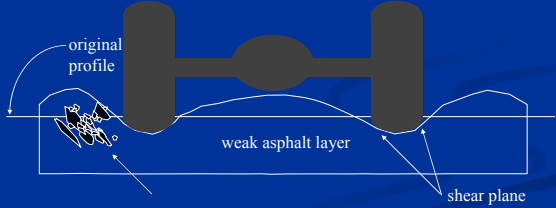


Effect of Polymer–Asphalt Binder Compatibility and Cross Link Density on Non-Recoverable Compliance in the Multi-Stress Creep and Recovery Test Method

John D'Angelo
Federal Highway Administration
Phone 202-366-0121 fax 202-493-2070
John.D'angelo@dot.gov

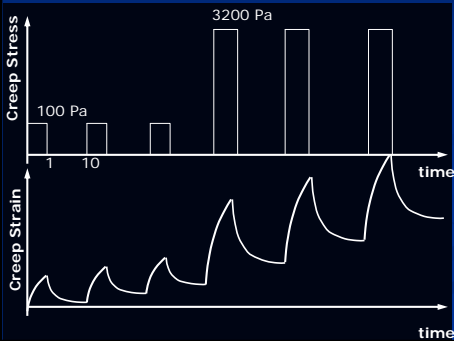
Review of the Multi-Step Creep and Recovery Work

Rutting in Asphalt Layer



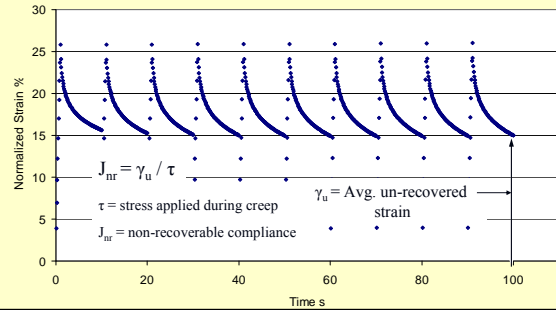
Movement and rotation of aggregate creates very high strain in the binder.

Multi Step Creep and Recovery



Test using the DSR applying a 1 sec creep stress followed by 9 sec recovery.

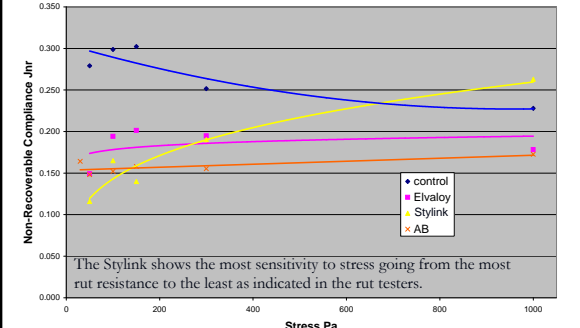
Determination of J_{nr}



$J_{nr} = \gamma_u / \tau$
 τ = stress applied during creep
 γ_u = Avg. un-recovered strain
 J_{nr} = non-recoverable compliance


J_{nr} of the binder from Rut Tester Study

MSCR shows stress sensitivity of binders

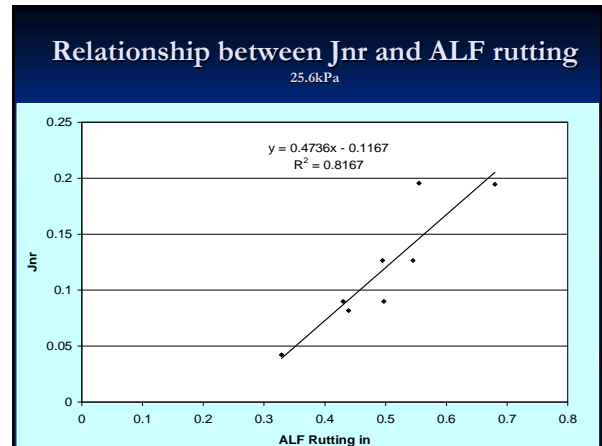
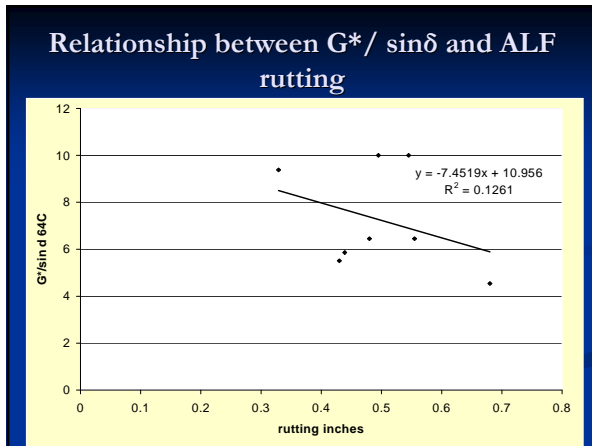


The Stylink shows the most sensitivity to stress going from the most rut resistance to the least as indicated in the rut testers.

7 Asphalt Binders

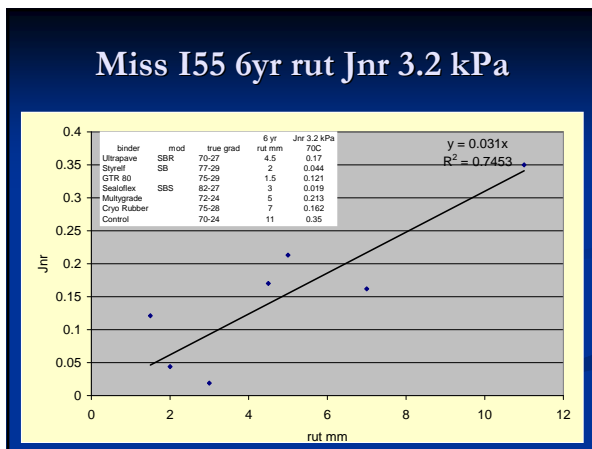
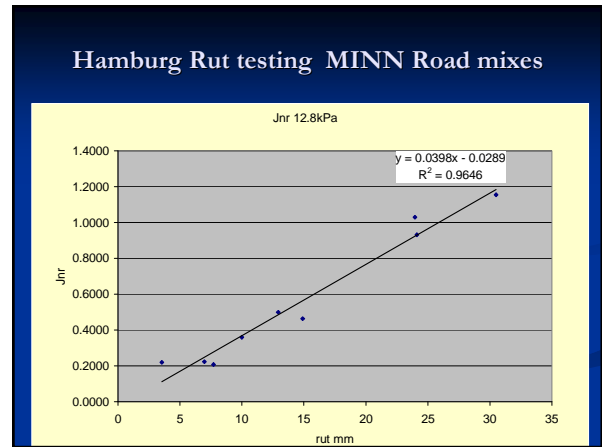


AZ CRM	PG 70-22	Air Blown	SBS	TX TBCR	TP	PG 70-22 + Fibers	PG 70-2264-40	SBS	Air Blown	SBS	TP
70-22	Control										
1	2	3	4	5	6	7	8	9	10	11	12



High Temperature Binder Criteria

- Linear binder tests will not correlate with high temperature mix failure test unless the binder is a viscous fluid at those temps.
- To accurately address mix failure non-linear binder properties have to be evaluated.
- Creep & Recovery testing of the binder at different stress levels is needed to describe binder properties in the non-linear range.



High Temperature Binder Criteria

- Non-recoverable compliance of the binder describes the stress dependency of the binder.
- Creep and recovery testing done at multiple stress levels on one sample can be run to describe the stress dependency of the binder.
- Creep and recovery non-recoverable compliance can be correlated to mix testing done at different stress conditions and related to performance.

Affect of Jnr on Rutting

- Reducing Jnr by half typically reduced rutting by half.
- This affect is seen on ALF sections and Hamburg Rut Testing
- But most importantly this is seen on the Mississippi I 55 sections.

Determination of a Specification criteria.

- The existing binder specification works very well for neat binders.
- The grading for neat binders should not change.
- Establish new Jnr criteria based on response of neat binders at their continuous grade temp.
- Evaluate the binders near the end of their linear range. Most neat binders remain linear up to 3.2 kPa stress.

Evaluation of Straight run binders

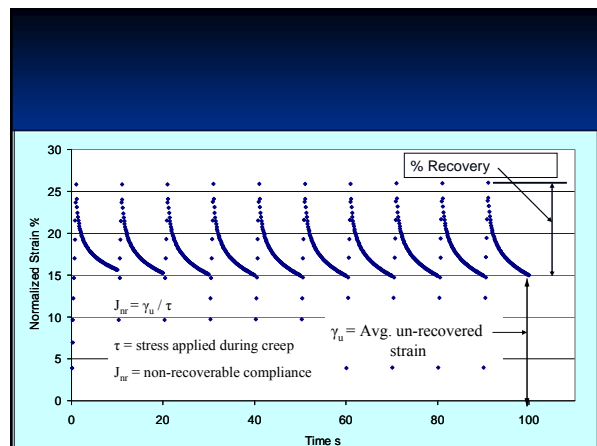
Sample ID	Name	Grade	true grade	Temp	Jnr 3.2kPa
ALF 6727	Control	70-22	72.7-74.2	72.7	0.439122
BBRS3	straight	64-22	66.1-27.3	66.1	0.418449
MN county rd 112	neat Valero	58-28	60.8-33.4	60.8	0.368445
MN county rd 112	neat Citgo	58-28	59.5-29.8	59.5	0.529647
MN county rd 112	AshlandM	58-28	60.7-31.4	60.7	0.430165
Minn Road	straight	58-28	61.8-30.8	61.8	0.302951
Miss I-55	CSL	67-22	68.3-25.1	68.3	0.266912
Shandong	straight	64-22	64.4-23.5	64.4	0.444057
BBRS3	straight	70-22	71.4-24.8	71.4	0.480855
BBRS3	straight	58-28	61.3-30	61.3	0.400345
MD project	straight	64-28	64.8-29.6	64.8	0.459335
average					0.412753

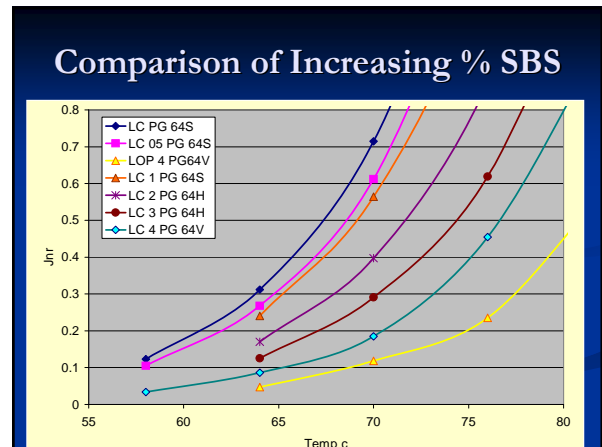
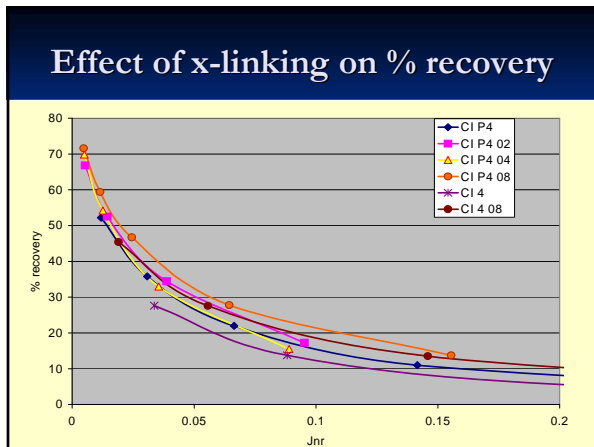
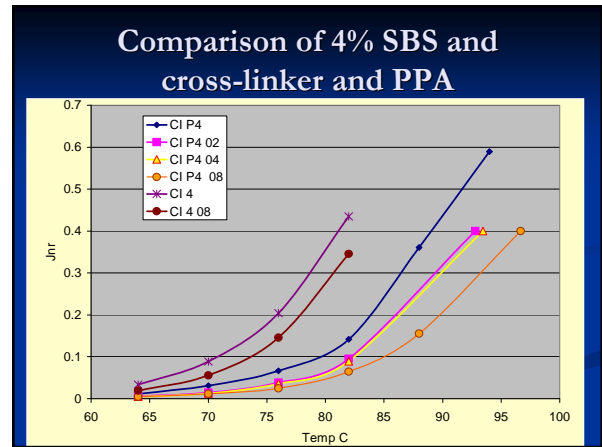
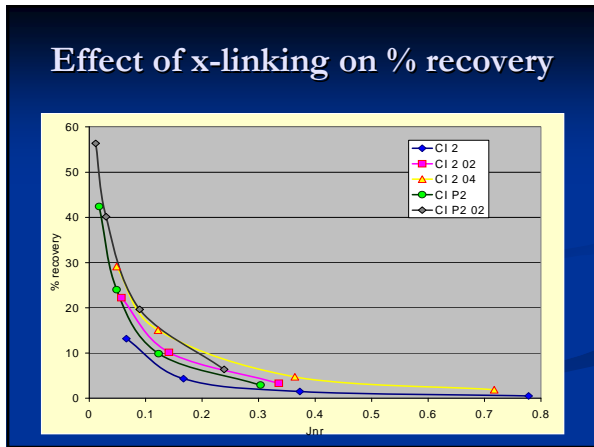
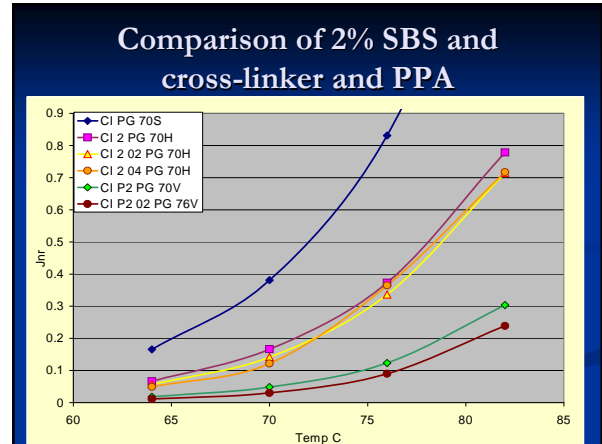
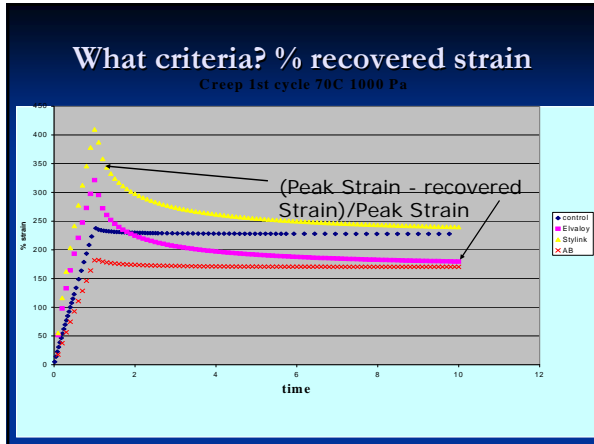
Grade bumping recommendation

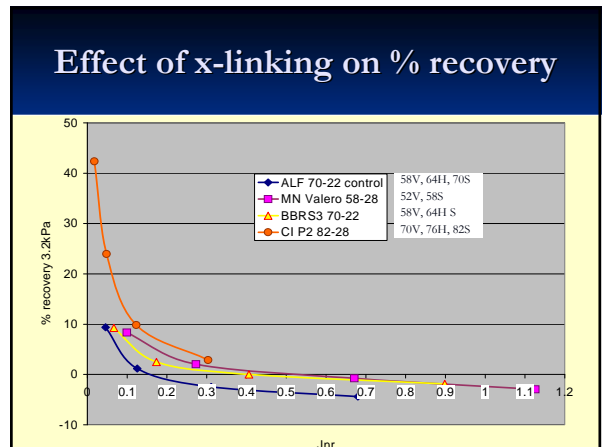
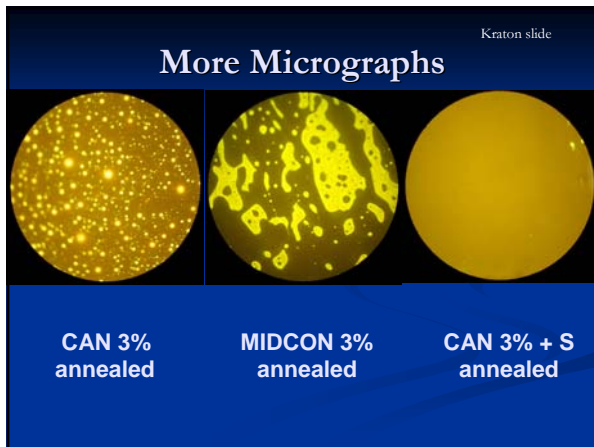
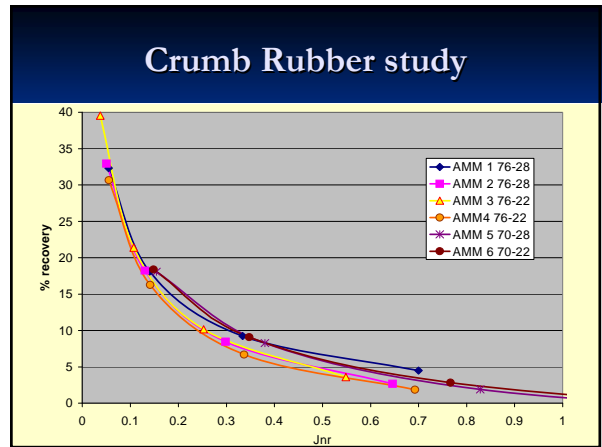
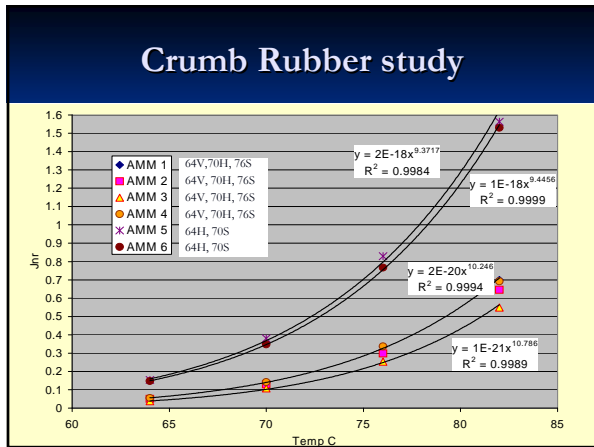
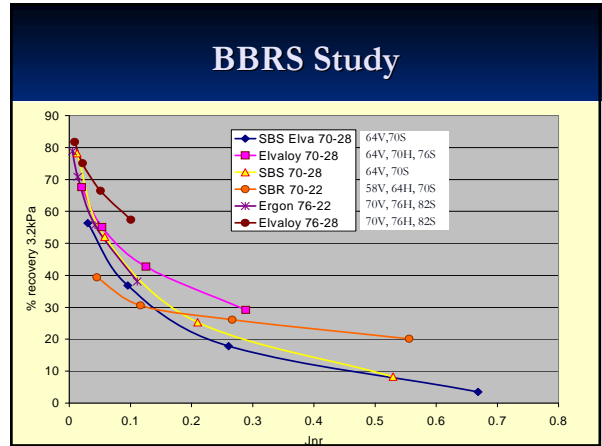
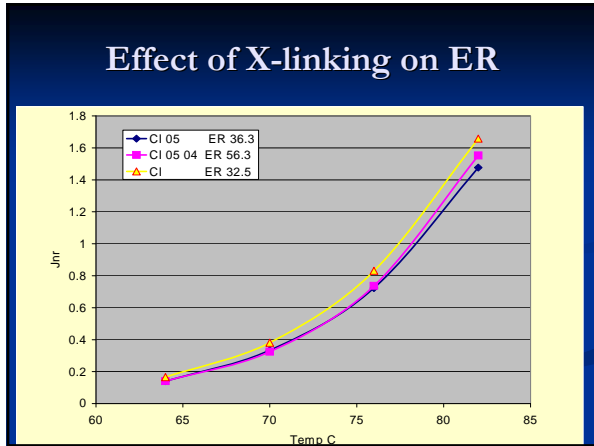
- All testing should be done at the environmental grade temp.
- The standard grade should be based on the Jnr value of existing neat binders 0.4 .
- For high traffic the Jnr value should be reduced by half at the grade temp to 0.2 .
- For standing traffic the Jnr value should be reduced by half again 0.1 .

New high Temp Spec

- PG 64 (Standard, Heavy, Very heavy) based on traffic.
 - PG 64S-XX $J_{nr} \leq 0.4$
 - PG 64H-XX $J_{nr} \leq 0.2$
 - PG 64V-XX $J_{nr} \leq 0.1$







New High Temperature Binder spec

- The new specification should be based on the non-recoverable compliance on the binder.
- All testing should be done at the pavement environmental grade temp to reflect response at actual operating temperatures.
- The test should be run at two stress levels 0.1 and 3.2 kPa ten cycles at each level. A comparison would be made to check how stress sensitive the binder is.
- Grade bumping should be done by halving the J_{nr} value.

Conclusions

- Blending and cross-linking process of the binder polymer system does effect performance properties.
- MSCR can identify how the polymer, binder and processing will affect performance in one simple test.
- The use of PPA and x-linker seem to work together to improve the performance properties of the binder as opposed to being used individually.

Thank You