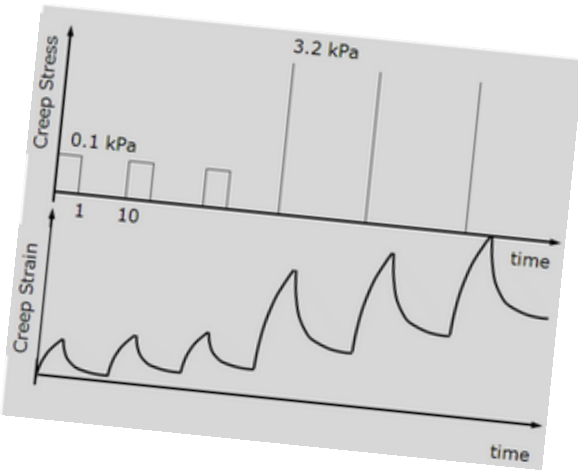


Simple Talking Points for Sharing Why Your State Should Be Implementing MSCR

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SEAUPG MSCR Task Group Web Meeting
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J_{nr}



**Recovered
Strain**

Many state Bituminous Engineers and Materials Engineers are finding that they need to be able to justify why they think their state should be implementing the MSCR test.

At the same time, many of the presentations over MSCR are filled with technical jargon and complicated charts which can make it difficult to communicate the basics to others who don't work with binder testing.

The presentation will cover the following bullet points, with their respective background info:

- The Superpave binder test system was based on a study of neat, not polymerized binders
- Why polymerized binders are different
- What the PG Plus test Elastic Recovery tells us and the time savings gained by eliminating it
- MSCR testing does a better job of predicting rutting susceptibility
- Making the MSCR jargon clear
- Implementation of MSCR



The use of polymer modified binders has grown tremendously over the past several years

However, the most widely used binder specification in the U.S., AASHTO M 320, **was based on a study of neat (unmodified) binders, and may not properly characterize polymer modified binders**

“Grade-bumping” to increase rutting resistance in AASHTO M 323

Table 1—Binder Selection on the Basis of Traffic Speed and Traffic Level

Design ESALs ^b (Million)	Adjustment to the High-Temperature Grade of the Binder ^a		
	Traffic Load Rate		
	Standing ^c	Slow ^d	Standard ^e
< 0.3	— ^f	—	—
0.3 to < 3	2	1	—
3 to < 10	2	1	—
10 to < 30	2	1	— ^f
≥ 30	2	1	1

^a Increase the high-temperature grade by the number of grade equivalents indicated (one grade is equivalent to 6°C). Use the low-temperature grade as determined in Section 5.

^b The anticipated project traffic level expected on the design lane over a 20-year period. Regardless of the actual design life of the roadway, determine the design ESALs for 20 years.

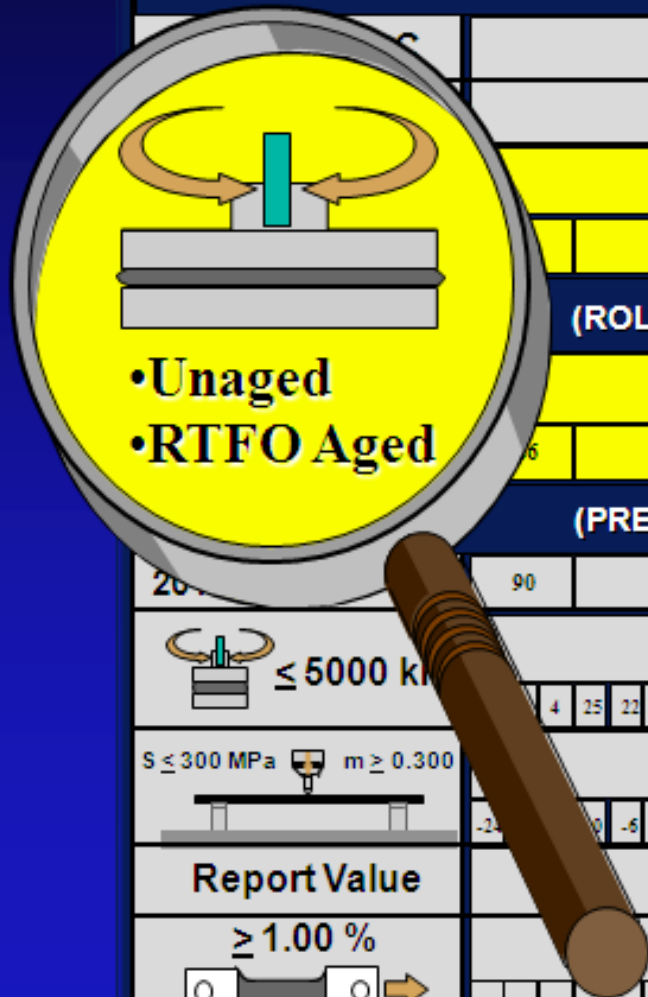
^c *Standing Traffic*—where the average traffic speed is less than 20 km/h.

^d *Slow Traffic*—where the average traffic speed ranges from 20 to 70 km/h.

^e *Standard Traffic*—where the average traffic speed is greater than 70 km/h.

^f Consideration should be given to increasing the high-temperature grade by one grade equivalent.

Permanent Deformation



Avg 7-day Max, °C	PG 46				PG 52				PG 58				PG 64				PG 70				PG 76				PG 82						
1-day Min, °C	-34	-40	-46	-10	-16	-22	-28	-34	-40	-46	-16	-22	-28	-34	-40	-10	-16	-22	-28	-34	-40	-10	-16	-22	-28	-34	-10	-16	-22	-28	-34
ORIGINAL																															
(Flash Point) FP																															
(Rotational Viscosity) RV																															
(Dynamic Shear Rheometer) DSR $G^*/\sin \delta$																															
52				58				64				70				76				82											
(ROLLING THIN FILM OVEN) RTFO Mass Loss $\leq 1.00\%$																															
(Dynamic Shear Rheometer) DSR $G^*/\sin \delta$																															
52				58				64				70				76				82											
(PRESSURE AGING VESSEL) PAV																															
90				90				100				100				100 (110)				100 (110)				110 (110)							
(Dynamic Shear Rheometer) DSR $G^* \sin \delta$																															
4 25 22 19 16 13 10 7 25 22 19 16 13 31 28 25 22 19 16 34 31 28 25 22 19 37 34 31 28 25 40 37 34 3 28																															
(Bending Beam Rheometer) BBR "S" Stiffness & "m"-value																															
-24 -30 -36 0 -6 -12 -18 -24 -30 -36 -6 -12 -18 -24 -30 0 -6 -12 -18 -24 -30 0 -6 -12 -18 -24 -30 0 -6 -12 -18 -24 0 -6 -12 -18 -24																															
(Bending Beam Rheometer) BBR Physical Hardening																															
(Direct Tension) DT																															
-24 -30 -36 0 -6 -12 -18 -24 -30 -36 -6 -12 -18 -24 -30 0 -6 -12 -18 -24 -30 0 -6 -12 -18 -24 -30 0 -6 -12 -18 -24 0 -6 -12 -18 -24																															

PG Grading Alone Does Not Always Predict Performance

- Study of the two mixes with the same aggregate structure, but different binders.

PG 63-22 modified, no rutting



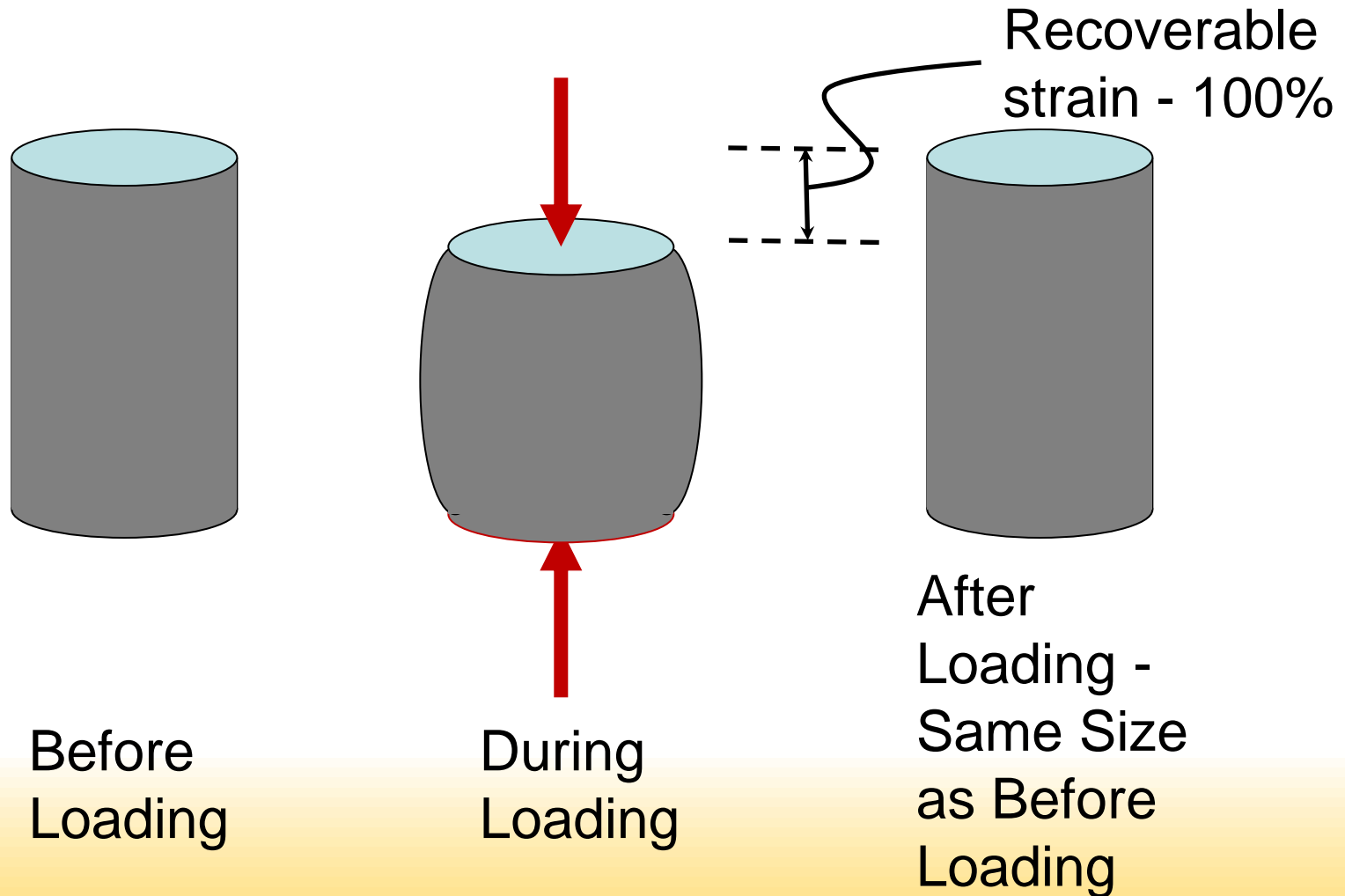
PG 67-22 unmodified, 15mm rut



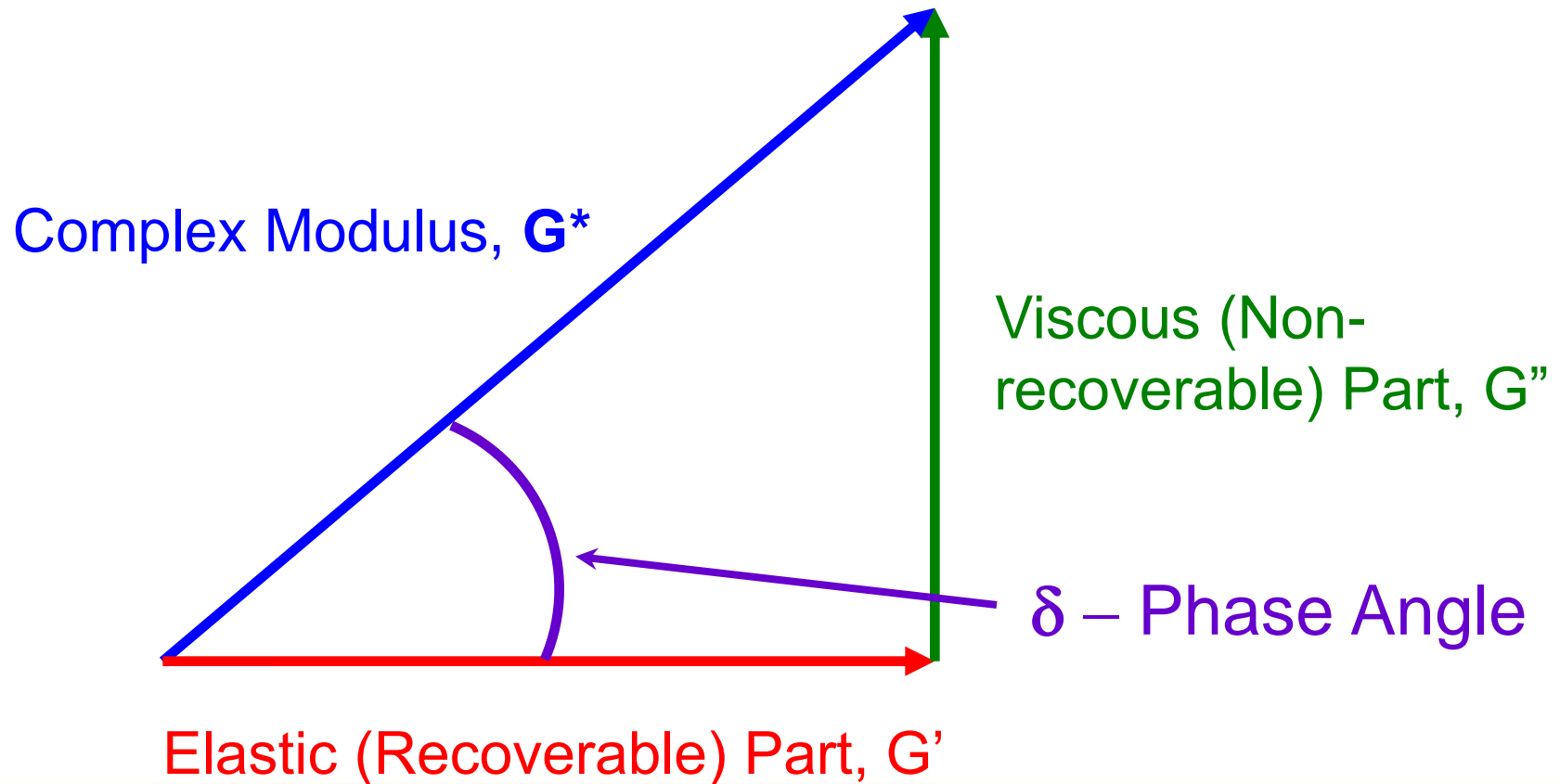
Why doesn't M 320 properly characterize polymer-modified binders?

- Current spec, G^* and δ are measured in the linear visco-elastic range.

How an Elastic Material Behaves



G^* is a measure of resistance to deformation

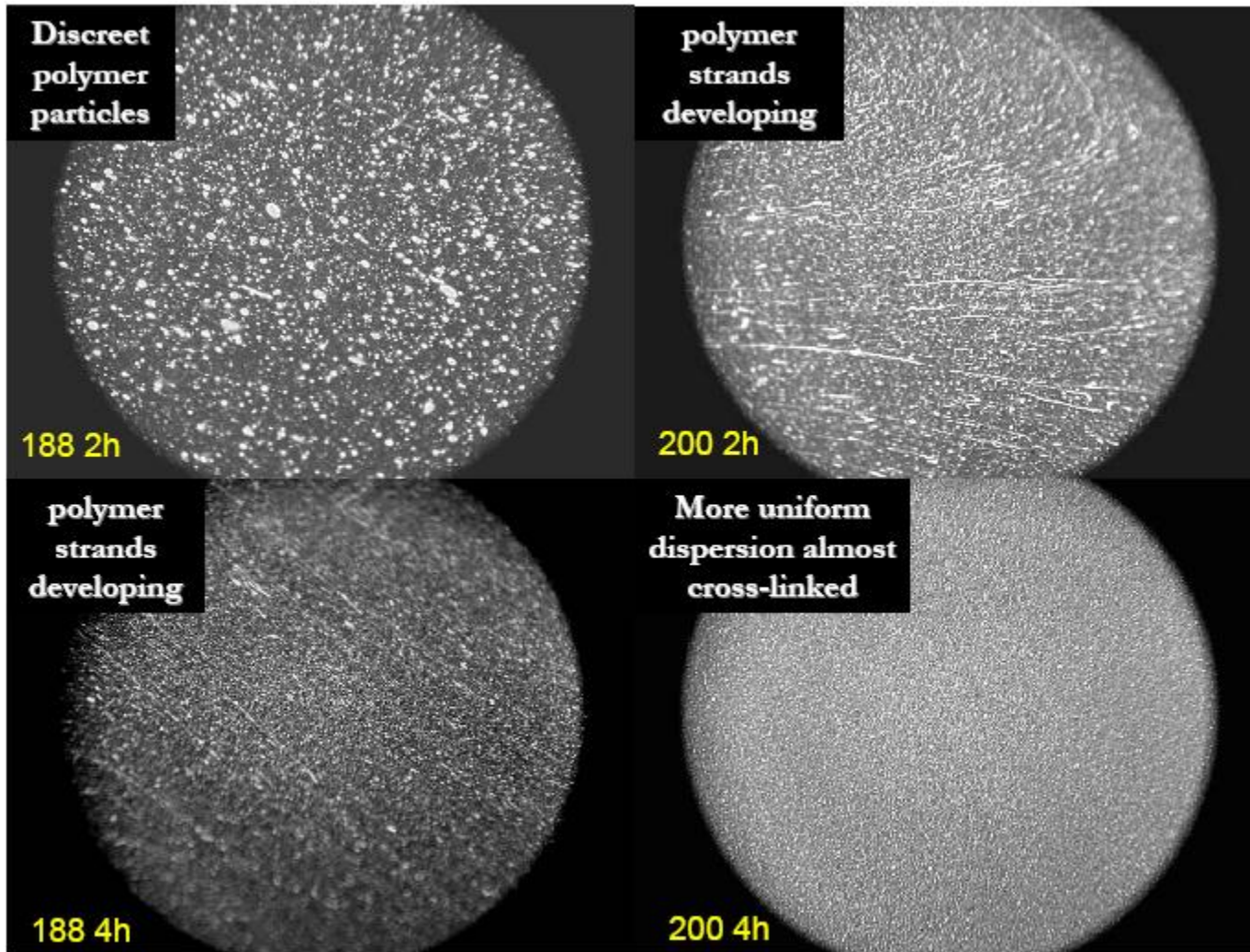


Complex Modulus is the vector sum of the elastic and viscous modulus

Why doesn't M 320 properly characterize polymer-modified binders?

- Current spec, G^* and δ are measured in the linear visco-elastic range.
- For neat asphalts, flow is linear and not sensitive to the stress level of the test.
- For polymer-modified binders, the response is not linear and sensitive to the stress level of the test. The polymer chains can be rearranged substantially as the stress increases.

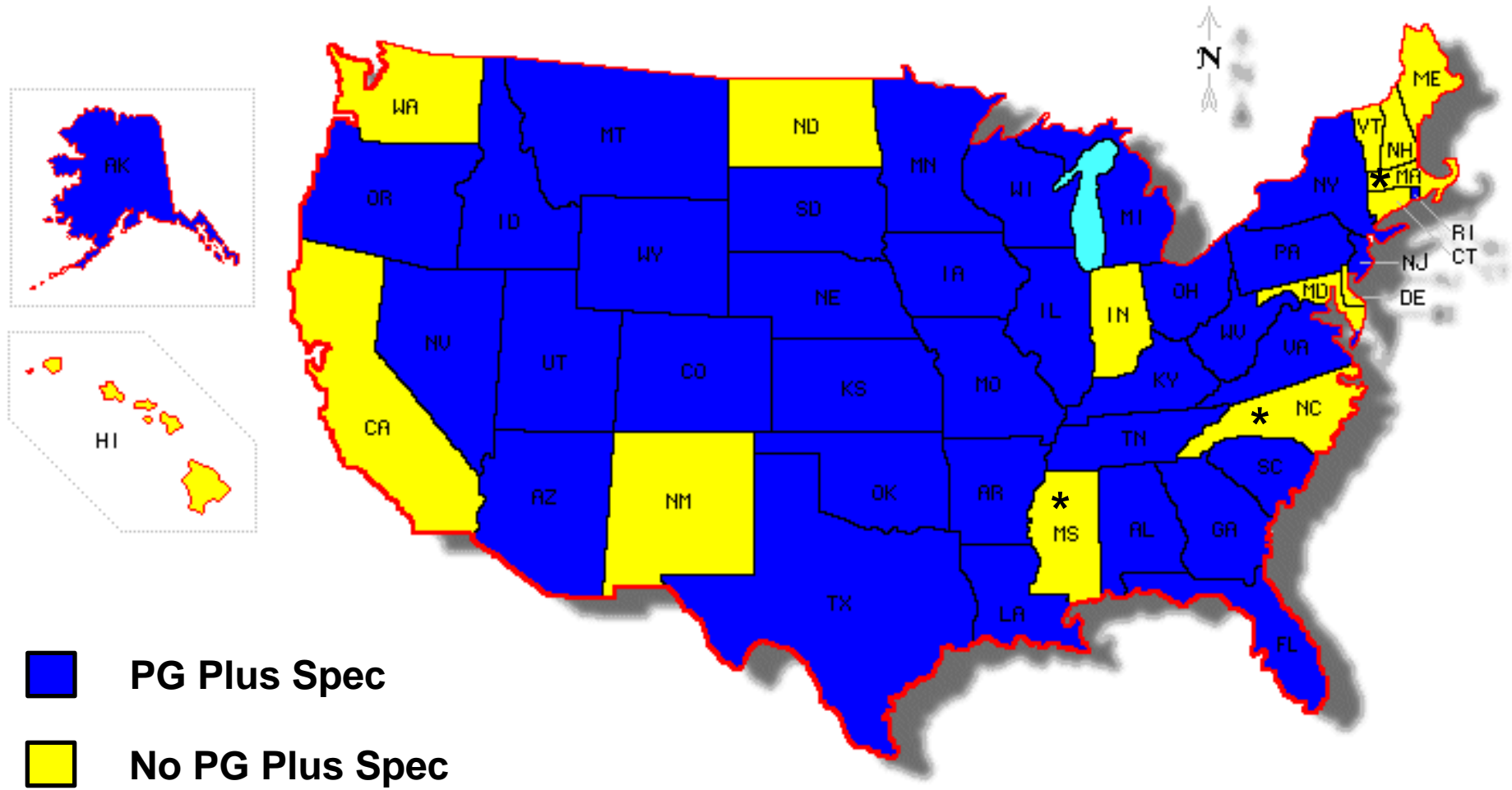
Same binder with same polymer may behave differently depending on blending



What happened as a result of M 320's inability to fully characterize polymer-modified binders?

- **Most states began requiring additional tests to the ones required in AASHTO M 320**
- **These mostly empirical tests are commonly referred to as “PG Plus” tests**
- **These tests are not standard across the states – difficult for suppliers**
- **Even some of the tests that are the most common, e.g. Elastic Recovery, are not run the same way from state to state**

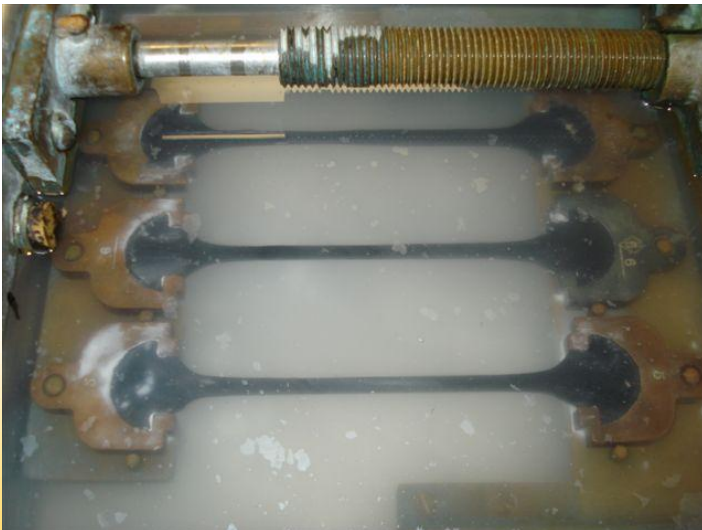
States with a “PG Plus” Specification



The Elastic Recovery Test

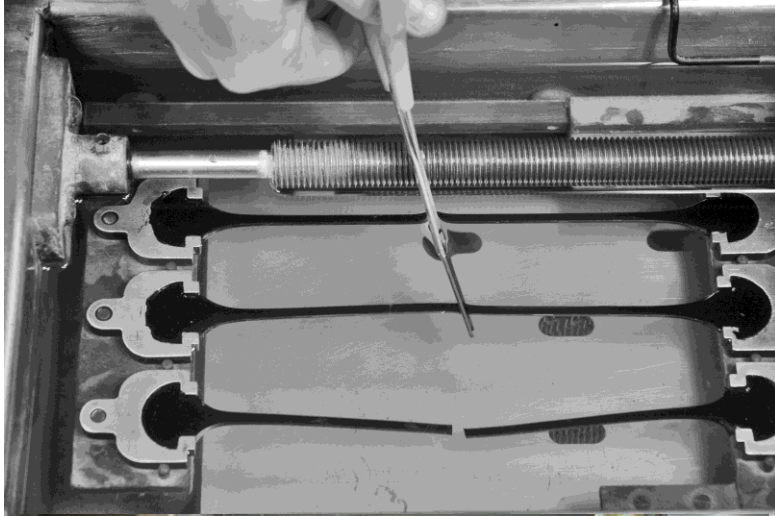


Step 1 - Equilibrate specimens to testing temperature, *typically* 25°C (77°F)

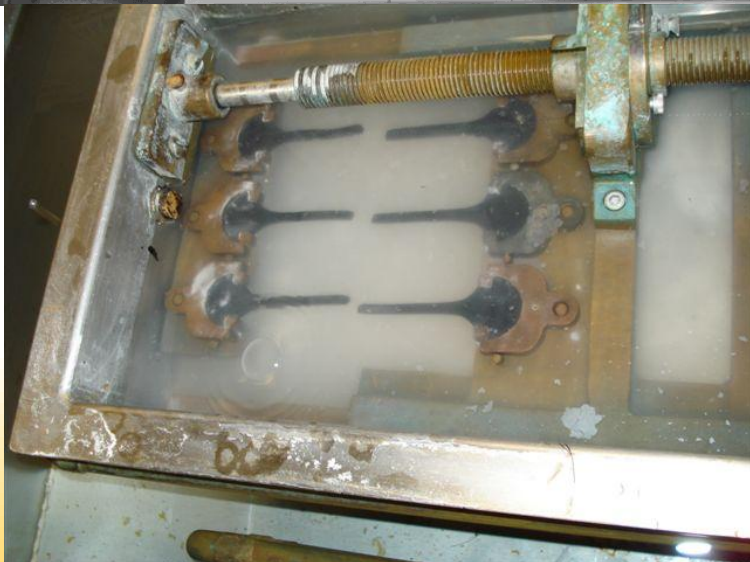


Step 2 – Stretch at controlled rate of 5 cm/min (2 in/min) to *typically* 20 cm (8 in)

The Elastic Recovery Test



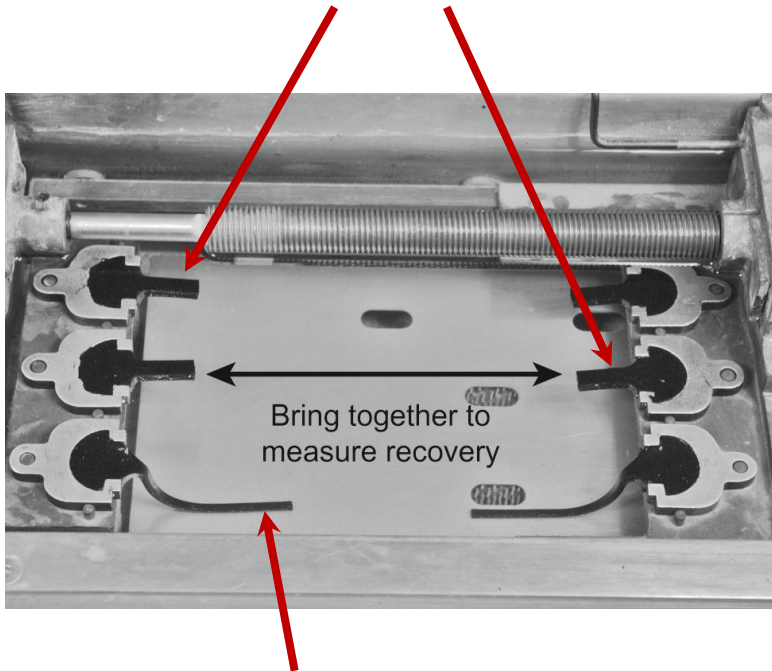
Step 3 – After holding stretched specimens in place for 5 min (*typically*), cut each in the center



Step 4 – (*Photo taken immediately after cutting*) Let sample stand undisturbed for 1 hour (*typically*)

The Elastic Recovery Test

Polymer-modified Samples



Neat (Unmodified) Sample

Step 5 – Retract ductilometer and measure distance until ends touch.

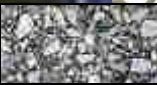




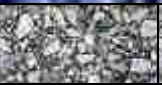


















$$\% \text{ Recovery} = \frac{\text{Total cm recovered}}{20 \text{ cm}}$$

ER Information and Test Time

- The Elastic Recovery Test is an excellent tool to establish the *presence* of polymer modification.
 - It takes about 4 hours to prepare and test samples for this information.
- However, it is a poor tool to evaluate the rutting *performance* of polymer-modified binders.
 - The MSCR test can use the same sample already being run in the DSR to give more information in a few extra minutes.

ALF Study - 7 Asphalt Binders

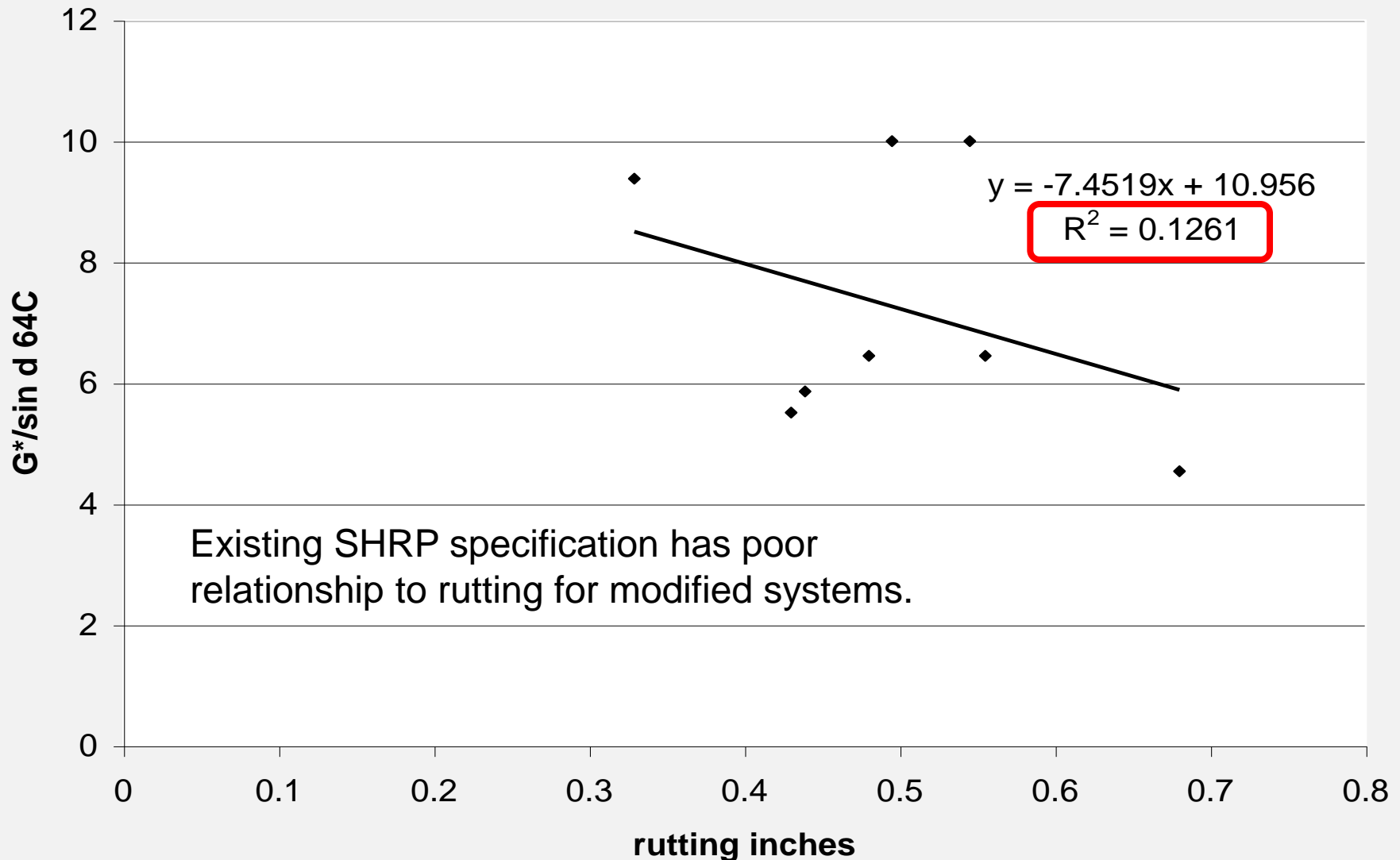


											
											
AZ CRM --- 70-22	PG 70-22 Control	Air Blown	SBS	TX TBCR	TP	PG 70-22 + Fibers	PG 70-22	SBS 64-40	Air Blown	SBS	TP
1	2	3	4	5	6	7	8	9	10	11	12

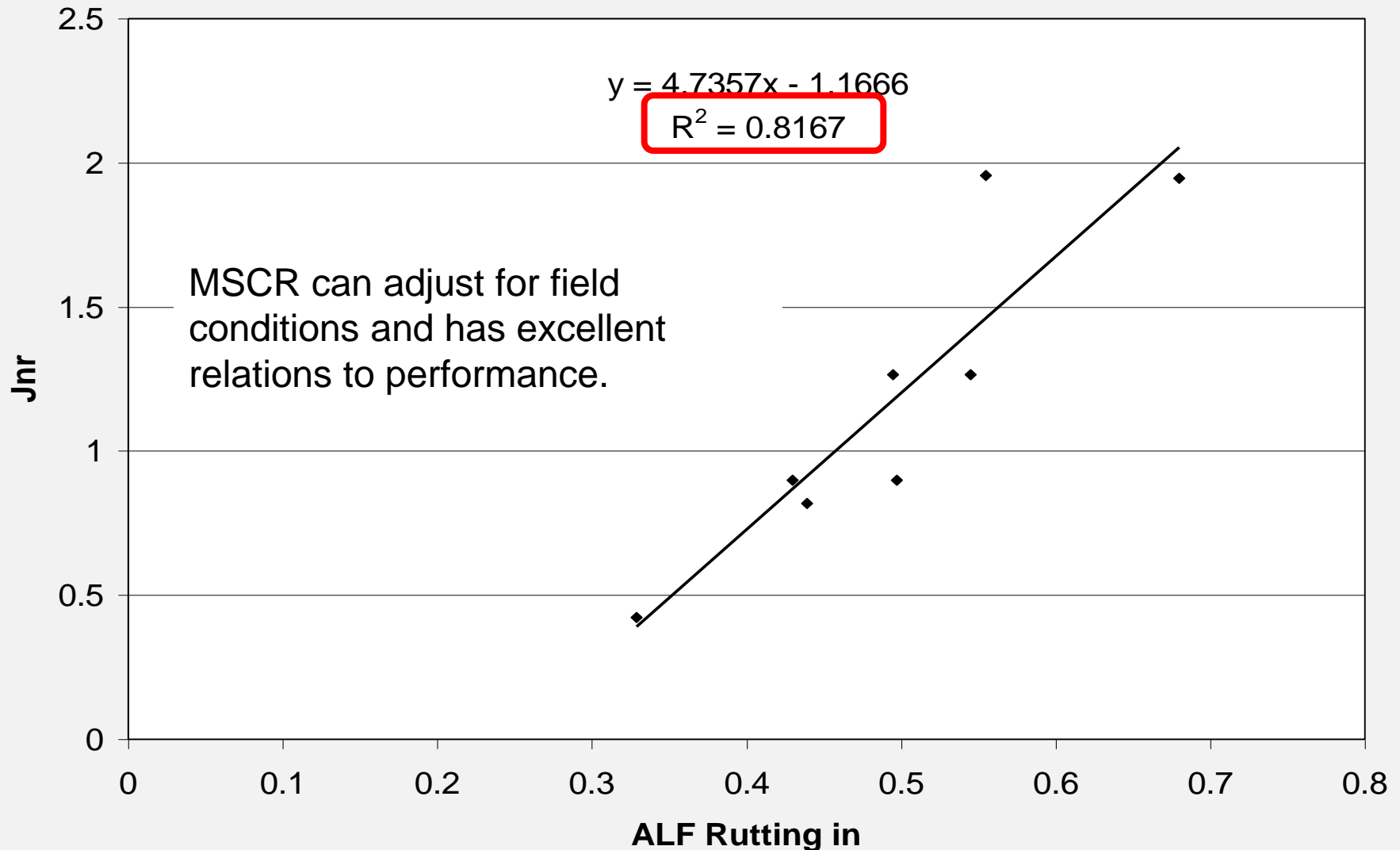
ALF Loading

- The pavement was heated to a constant 64°C.
- The FHWA ALF uses an 18,000 lbs wheel load with no wheel wander.
- The speed is 12 MPH.
 - This is an extreme loading condition far more severe than any actual highway.

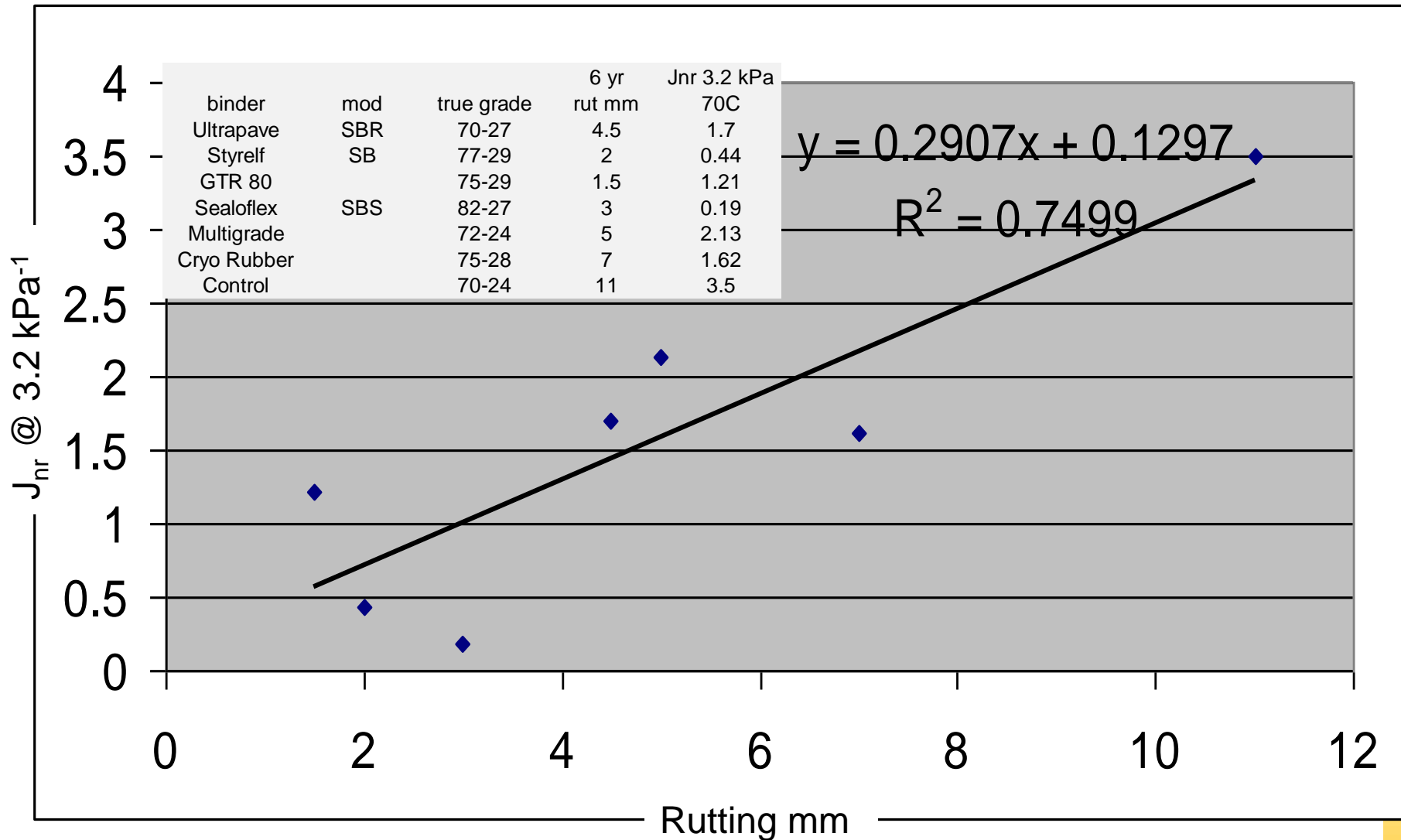
Relationship between $G^*/\sin \delta$ and ALF rutting



Relationship between Jnr and ALF rutting



Mississippi I-55 6-year rutting study



MSCR Overview Talking Points

The Multiple Stress Creep Recovery test, commonly referred to as the MSCR (pronounced *massacre*) test, is an asphalt binder test which:

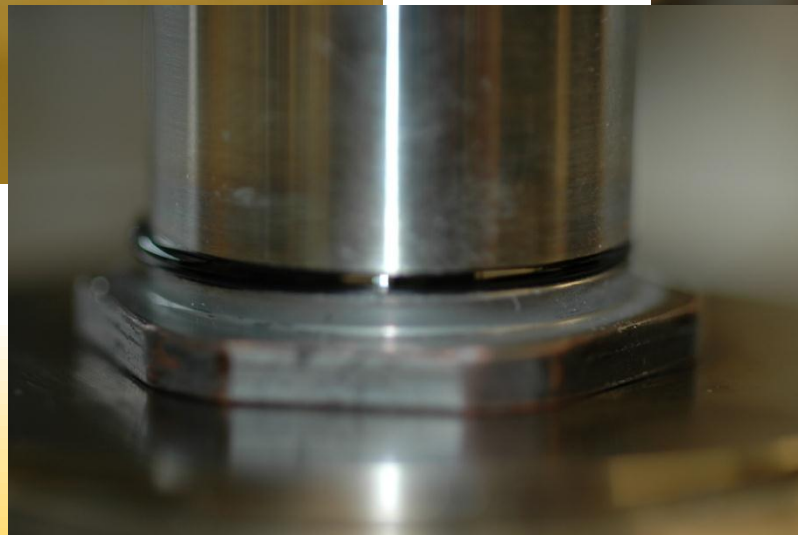
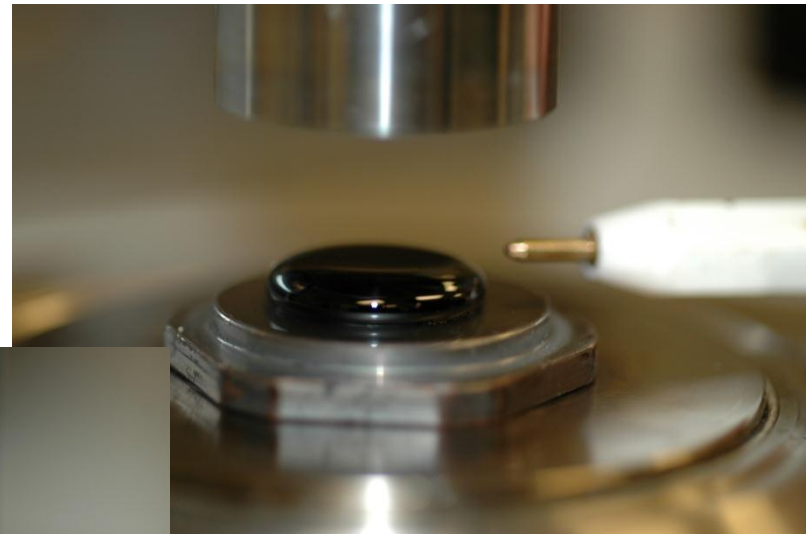
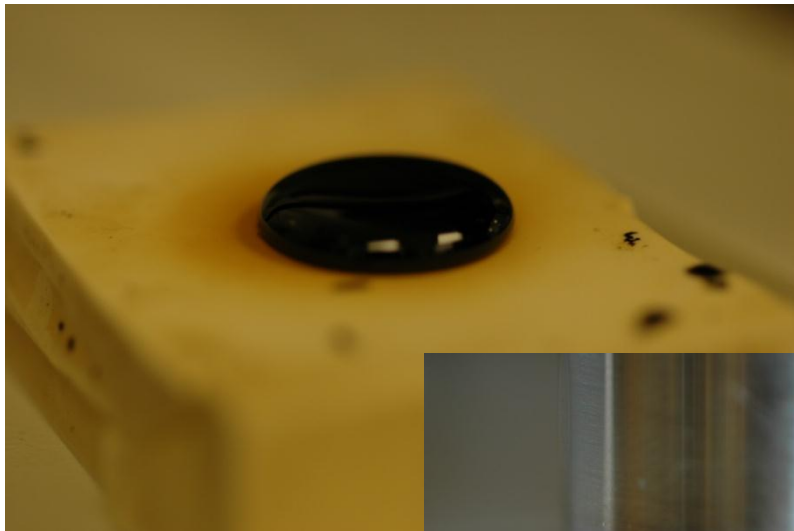
- allows for a performance-related binder spec that is blind to modification type
- can relate polymer-modified binders' potential rutting performance to in-service pavements
- allows for a much more economic use of polymers to improve performance

Multiple Stress Creep Recovery

- The test method is detailed in AASHTO TP 70
- The test uses the same Dynamic Shear Rheometer (DSR) as required in the original M 320
- Only minor software changes are needed to run the MSCR test
- The test uses the creep and recovery method to measure the *percent recovery* and *non-recoverable creep compliance* (J_{nr})

Multi Stress Creep and Recovery

- Sample prep is exactly the same as the existing RTFO DSR.



Multiple Stress Creep Recovery

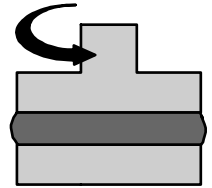
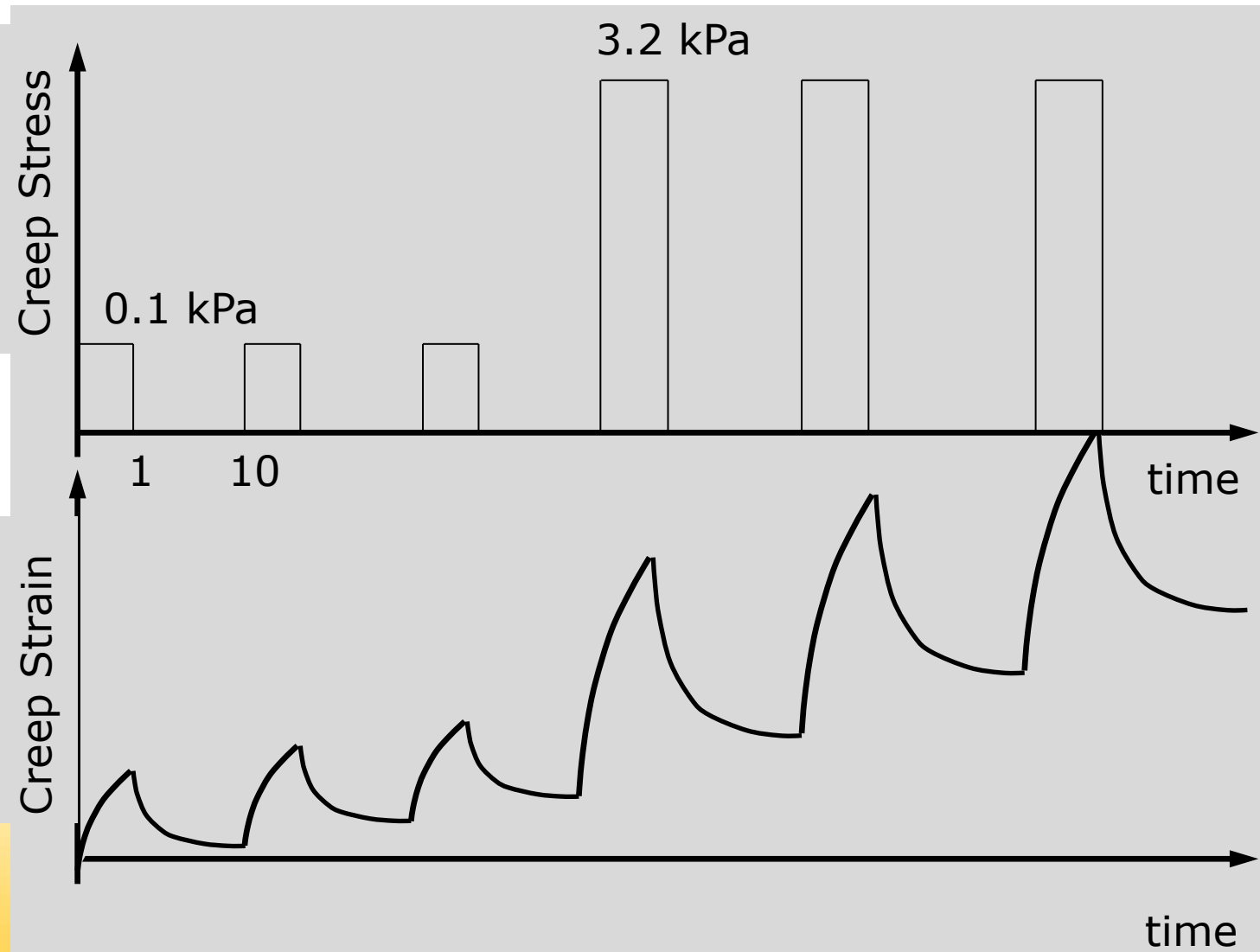
Definitions:

Creep and recovery – a standard test protocol whereby a specimen is subjected to a constant load for a fixed time period and then allowed to relax (recover) at a zero load for a fixed time period

Percent Recovery – A measure of how much the sample returns to its previous shape after being repeatedly stretched and then relaxed

Non-Recoverable Creep Compliance (J_{nr}) – a measure of the amount of residual strain left in the specimen after repeated creep and recovery, relative to the amount of stress applied

Multi Stress Creep and Recovery



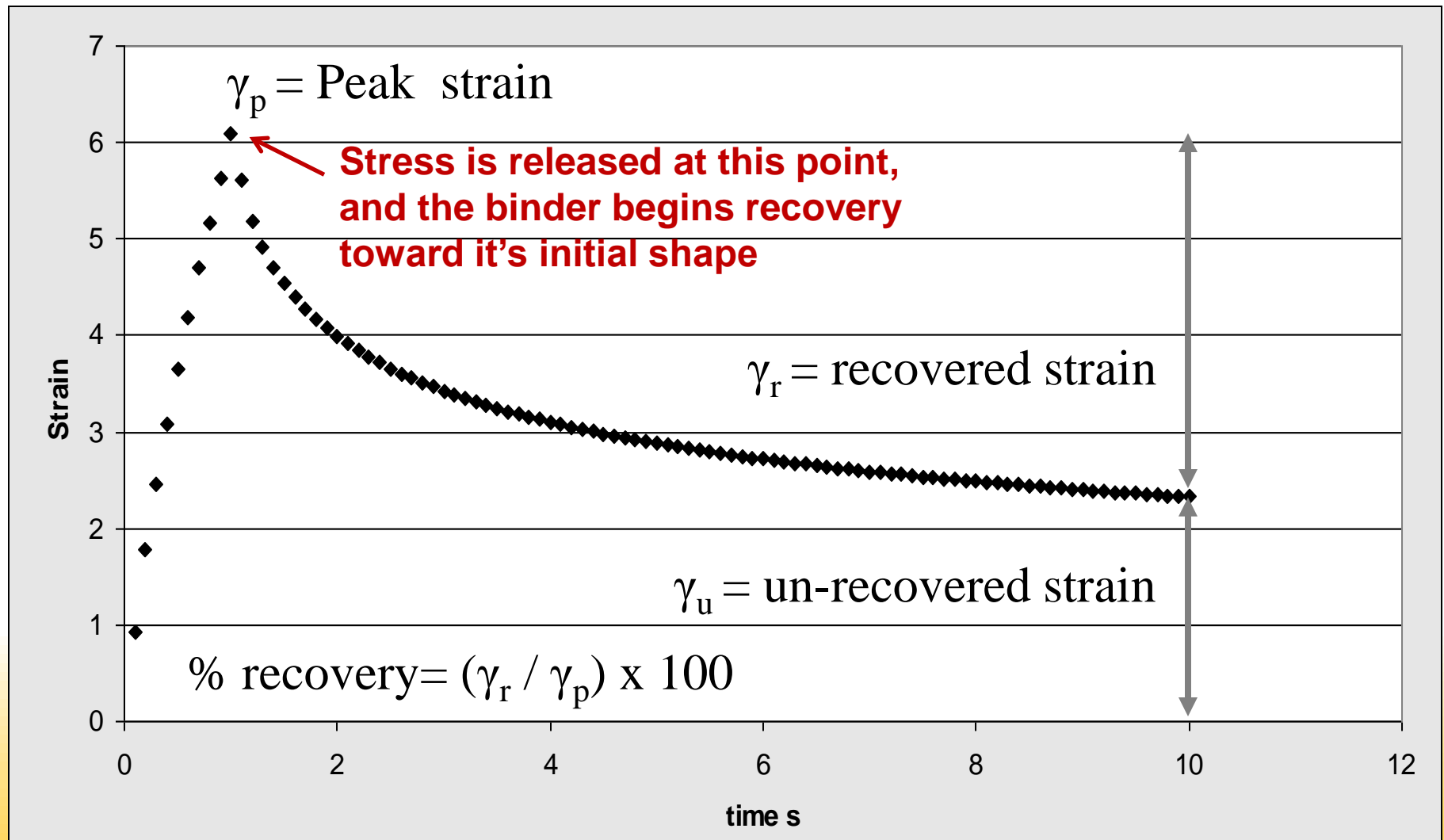
Test using the DSR applying a 1 sec creep stress followed by 9 sec recovery.

Stress Sensitivity Parameter

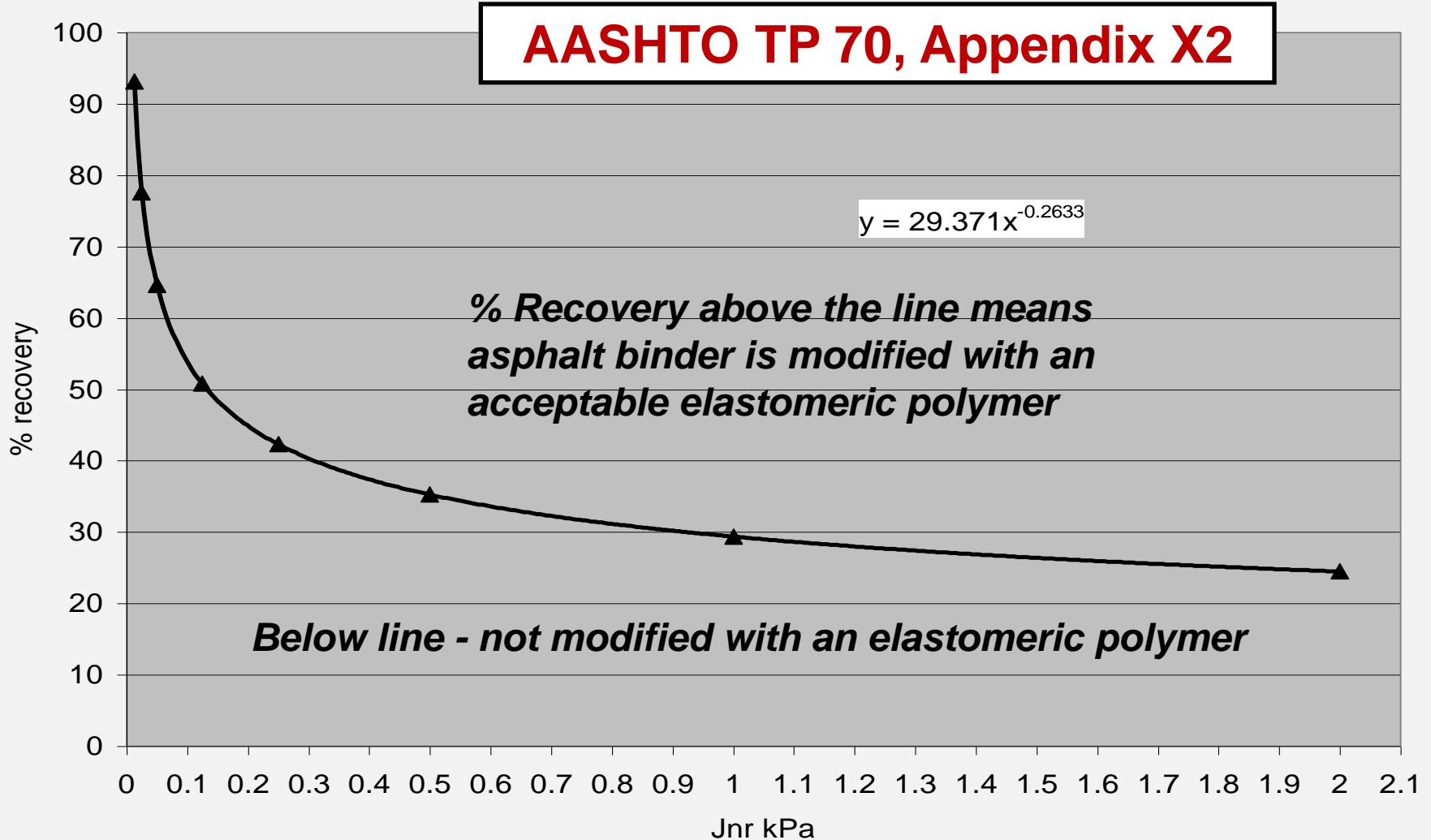
$$J_{nr, \text{diff}} = \frac{(J_{nr, 3.2\text{kPa}} - J_{nr, 0.1\text{kPa}})}{J_{nr, 0.1\text{kPa}}} \times 100 \leq 75\%$$

For polymer-modified binders, the strain response is not linear and sensitive to the stress level of the test. The polymer chains can be rearranged substantially as the stress increases. *This parameter is a check on the phenomenon.*

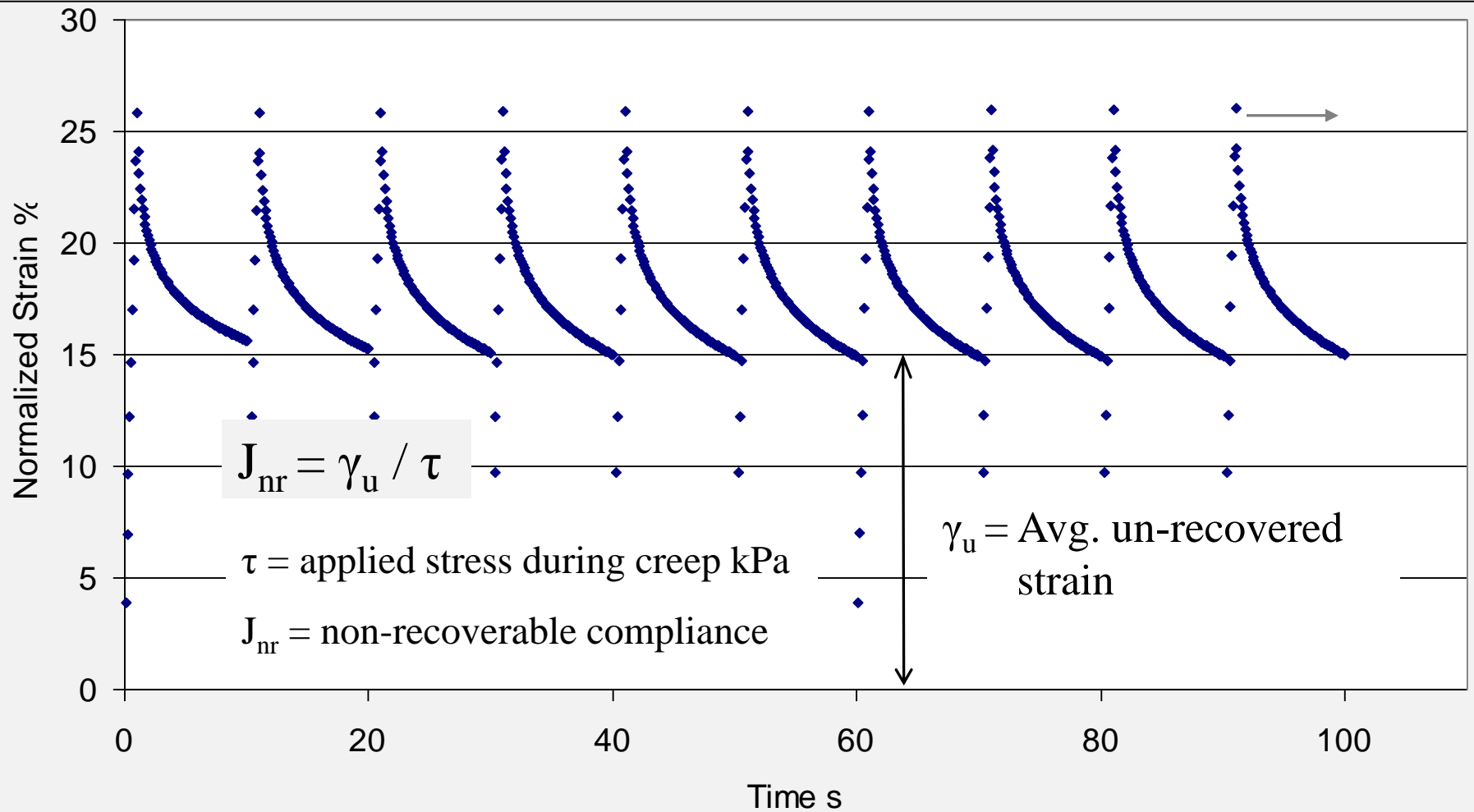
What is % Recovered Strain?



MSCR % recovery can be added to validate polymer modification



Determination of J_{nr}



Effect of J_{nr} on Rutting

- Reducing J_{nr} by half typically reduced rutting by half.
- The effect is seen in the lab on Accelerated Loading Facility sections and Hamburg Rut Testing
- More importantly, it is also seen in the field, for example the Mississippi I-55 research.

Implementation

Please recognize that the refineries that serve your state may also serve bordering states.

This may be a good reason for an unusual implementation process - working with other states to implement regionally

Note that every current Performance Grade may not equate to a distinct MSCR grade - for example, the polymer loading in both a PG 70-22 and PG 76-22 may be high enough that both grade to a “PG 64-22 E”

New PG Grading System (MSCR)

- Environmental grade plus traffic level designation; i.e. PG 64-22E
 - Four traffic levels
 - S = Standard: < 10 million ESALs and standard traffic loading
 - H = Heavy: 10 – 30 million ESALs or slow moving traffic loading
 - V = Very Heavy: > 30 million ESALs or standing traffic loading
 - E = Extr. Heavy: > 30 million ESALs and standing traffic loading

Full vs. Partial Implementation

Some agencies may be reluctant to implement MSCR fully, since the names by which they refer to binder types will necessarily change.

“PG 64-22 H” instead of “PG 70-22,” for a possible example

If this is the case, a partial MSCR implementation could be done as outlined in AI’s “Guidance on the Use of the MSCR Test with the AASHTO M 320 Specification.”

Full vs. Partial Implementation

Importantly, AI recommends that if the MSCR test is implemented to evaluate the delayed elastic response of binders, then other PG Plus tests with a similar purpose - such as Elastic Recovery, Force Ductility, and Toughness and Tenacity tests - *should be eliminated*.

If you are conducting side-by-side testing for a while as a precaution, keep in mind that these types of tests give much more simplified results with a much higher degree of error than the MSCR, so agencies should not expect a strong correlation between them and MSCR results.



Questions?