


Louisiana's Experience on Multiple Stress Creep Recovery (MSCR) Test


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Outline

- Background
- MSCR Test Method
- AASHTO MP 1g Binder Specs
- LTRC's Study
- Findings
- Conclusions & Recommendations

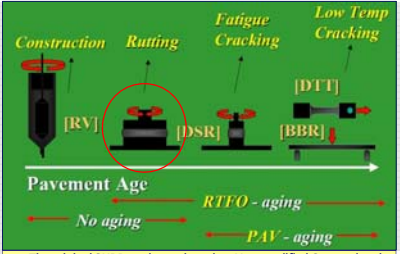


Research Team


- William "Bill" King, Jr., P.E. (Co-Principal Investigator)
- Patrick Frazier, Jeremy Icenogle, and William Gueho (Laboratory Assistants)



Background: PG System




- The original SHRP study was based on Non-modified Conventional Binders.
- Current DSR Specification:
 - $G^*/\text{Sin}\delta = 1.00^*$ [For original binders]
 - $G^*/\text{Sin}\delta = 2.20^*$ [For RTFO binders]

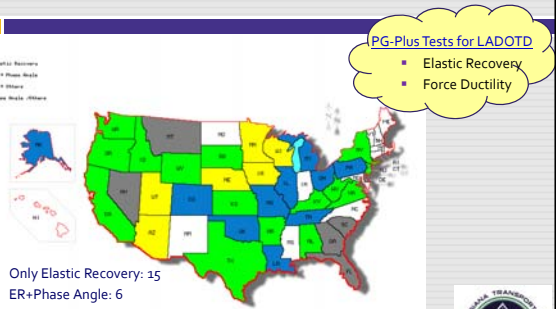


Limitations of PG System

- $G^*/\text{Sin}\delta$ is not adequate to reflect the Delayed Elasticity of polymer modified binders.
- Existing grading system cannot discriminate between more or less effective modification technologies.
- Required PG+ Test.




PG+ Tests



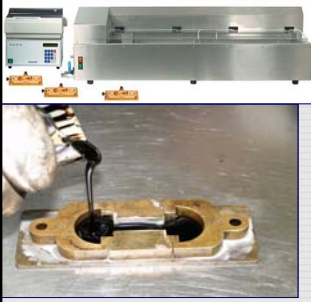
PG-Plus Tests for LADOTD

- Elastic Recovery
- Force Ductility


- Only Elastic Recovery: 15
- ER+Phase Angle: 6
- ER+Others: 10
- Phase Angle+Others: 6
- None: 13



Elastic Recovery Test




- Approximate Test time: 4-5 hrs
- More Binder Sample: 50 gms (apprx)
- Molds: Parallel, V-shape
- Elongation: 10 cm / 20 cm
- Temperature: 10°C / 25°C
- Wait Time: Immediate / 5 mins.





Why MSCR?

- Better correlation with rutting potential.
- Can save cost & time.
- Other entities showed interest in MSCR test.
- Overly stress sensitive binders that may pass the current PG system can be eliminated.
- No Grade bumping.
- Can be used to evaluate new asphalt modifier.

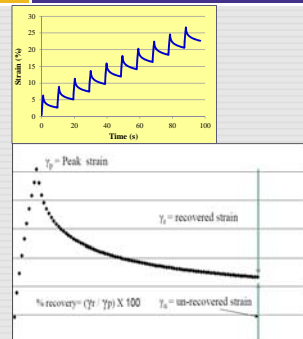


MSCR Test Parameters


- AASHTO TP 70
- DSR, 25 mm plate, 1 mm gap
- Stress Levels: 100 & 3200 Pa
- 10 cycles / Stress level
- Creep Stress Time: 1 sec
- Recovery Time: 9 sec
- RTFO Aged Binder Samples

MSCR Test : Resulting Parameters




- Non-Recoverable Creep Compliance
 $J_{nr} = \gamma_r / \sigma$
- % Recovery
 $[\gamma_r / \gamma_p] \times 100$
- % difference between Jnr @ 3200 & 100 Pa
- Difference between avg. % Recovery @ 100 & 3200 Pa



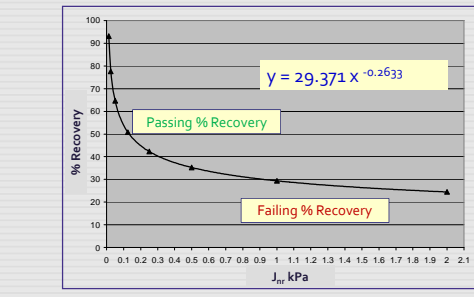
AASHTO MP 19 Specifications

Climatic Temperature: High 64°C, Low: -22°C

Traffic Level (ESALs, millions)	New PG Grade Designation	Original Binder DSR (T315) @ 64°C	RTFO Binder MSCR (TP70) @ 64°C		PAV Binder DSR (T315) @ 25°C
			$J_{nr\ 3-2}$	$J_{nr\ diff}$	
Standard (<10 m)	PG 64-22S	$G^* / \sin \delta \geq 1.0$ (kPa)	≤ 4.0 (kPa ⁻²)	$\leq 75\%$	$G^* \sin \delta \geq 5000$ (kPa)
Heavy (10-30 m)	PG 64-22H		≤ 2.0 (kPa ⁻²)	$\leq 75\%$	
Very Heavy (>30 m)	PG 64-22V		≤ 1.0 (kPa ⁻²)	$\leq 75\%$	
Extreme (>30 m + Standing Traffic)	PG 64-22E		≤ 0.50 (kPa ⁻²)	$\leq 75\%$	




MSCR Test : Resulting Parameters



Passing % Recovery

Failing % Recovery



LTRC's Study Plan

- LTRC Project # 11-1B
Validity of Multiple Stress Creep Recovery (MSCR) Test for LADOTD Asphalt Binder Specifications.
- Characterize the elastic response of asphalt binders commonly used in Louisiana.
- Feasibility of MSCR test to be included in LADOTD binder specification
- Correlation between MSCR and other PG-Plus binder test (i.e. Force Ductility, Elastic Recovery) results.



What LTRC Did

- SBS Polymer Modified PG 76-22m: 21 binders
- SBS Polymer Modified PG 70-22m: 24 binders
- Rubber Modified: 9 binders
- Latex Modified PG 70-22m: 2 binders
- WMA Binders: 7 binders
- 3 replicates per binder for MSCR testing
- Tested both Unaged and RTFO aged binders at 64°C and 70°C
- Elastic Recovery Tests: RTFO aged binders @ 25°C
- Force Ductility Tests: Original binders @ 4°C & 5 cm/min elongation



Test Factorial: Polymer Modified Binder

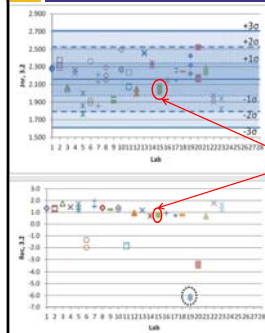
Binder Source	PG 76-22m					PG 70-22m					
Supplier 1	A1	A2	A3	A4	A5	Z1	Z2	Z3	Z4	Z5	
Supplier 2	B1	B2	B3	B4		Y1	Y2	Y3	Y4	Y5	Y6
Supplier 3	C1	C2	C3	C4		X1	X2	X3	X4	X5	
Supplier 4	D1	D2				W1	W2	W3			
Supplier 5	E1	E2				V1	V2	V3			
Supplier 6	F1	F2				U1	U2				
Supplier 7	G1	G2									



Test Results



SEAUPG Inter-laboratory Study



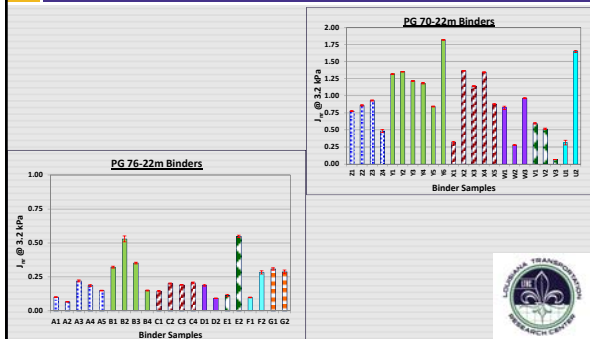
- Participants:
 - 13 User Labs (State DOTs/FHWA)
 - 8 Asphalt Producer Labs
 - 2 Academia

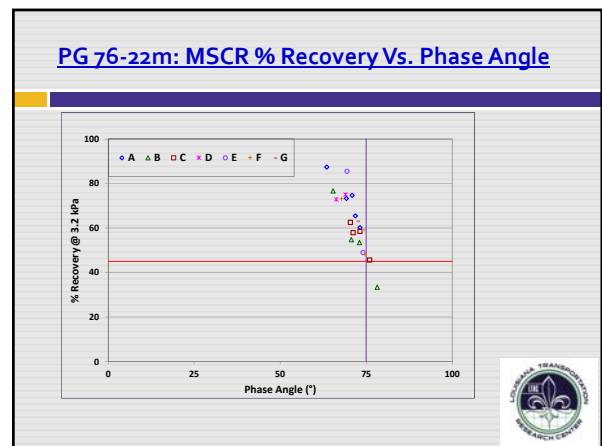
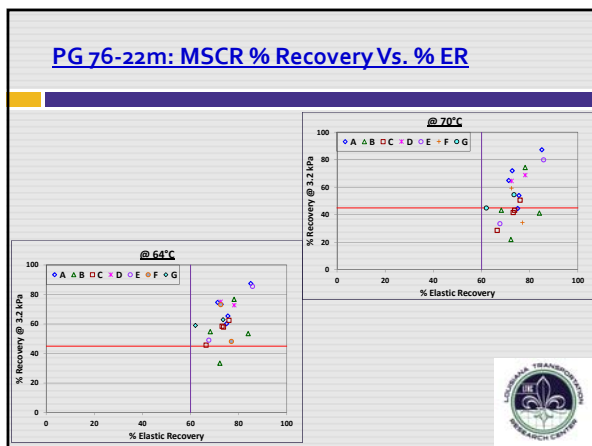
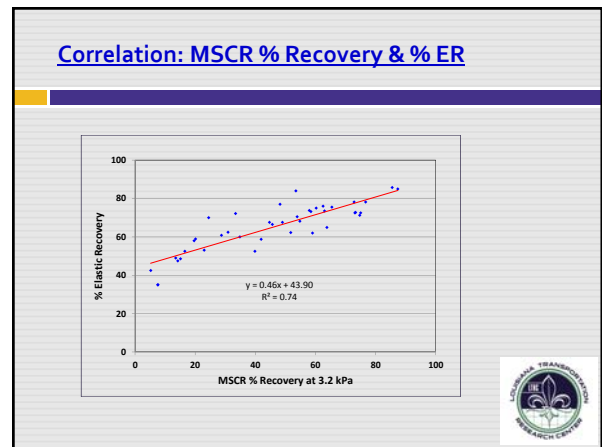
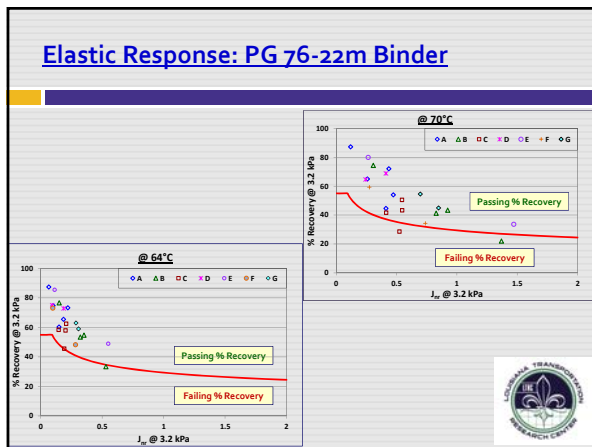
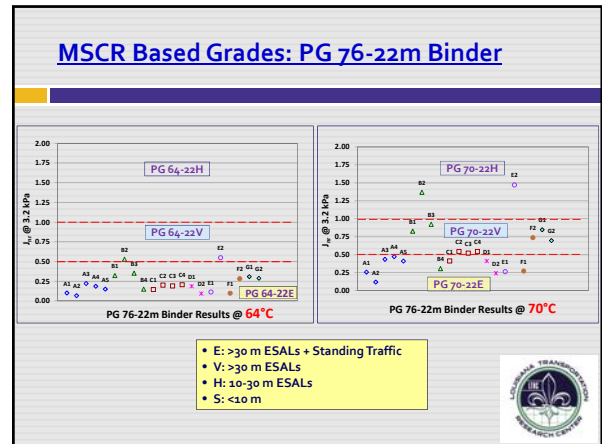
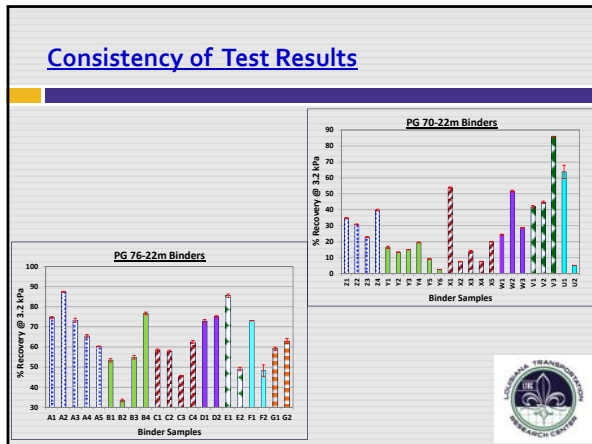
LTRC's Data

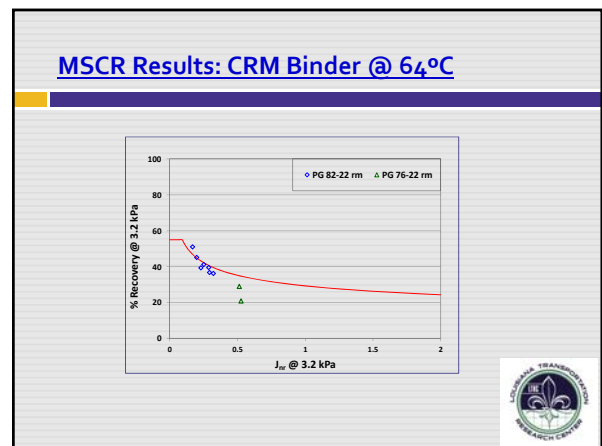
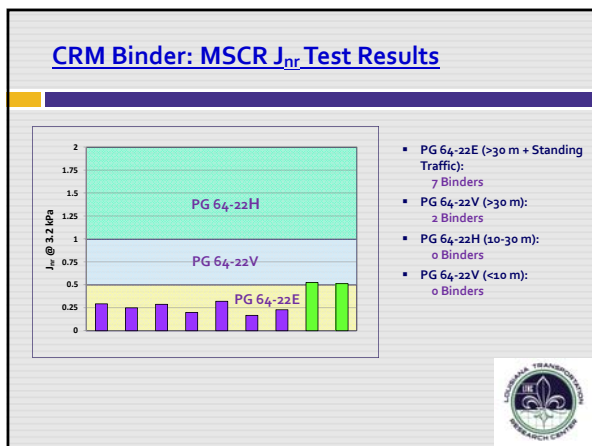
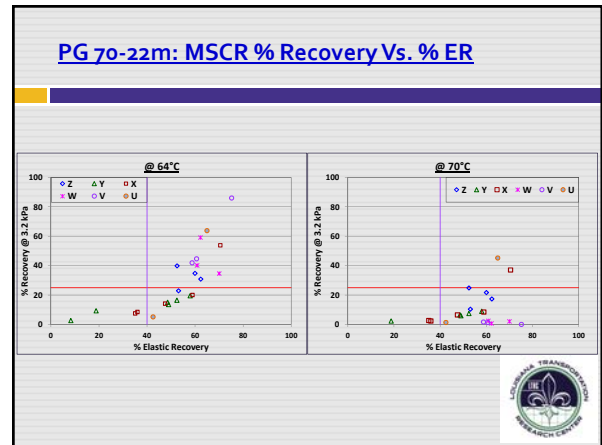
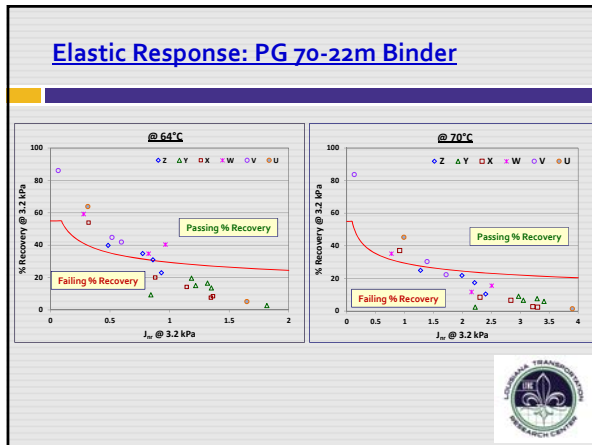
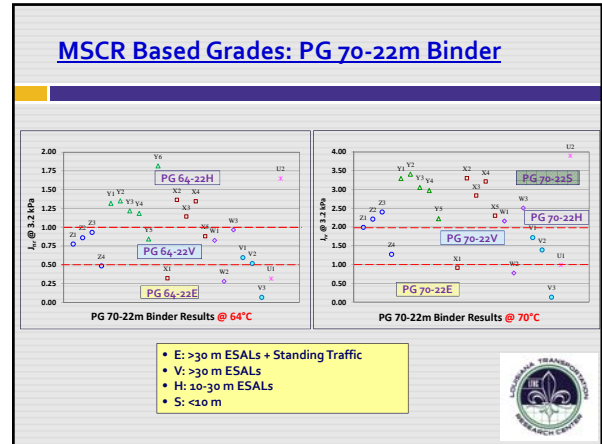
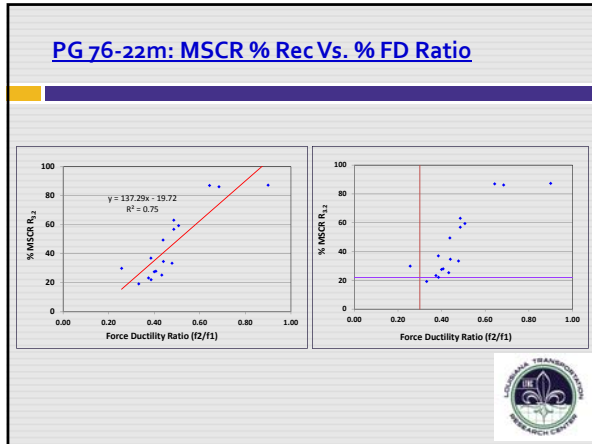
Courtesy: Michael Anderson, P.E.
Asphalt Institute



Consistency of Test Results







Preliminary Findings:

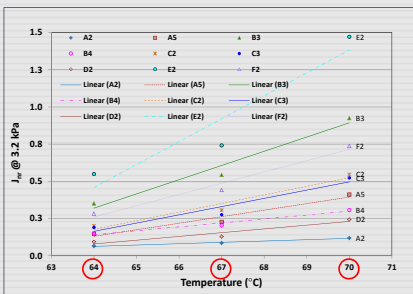
- The MSCR test was found to be **more discriminating** to characterize the stress dependency of polymer modified binders.
- The MSCR test and the corresponding specifications were found to be an **improvement** to the current PG binder specifications for LADOTD.
- None of the binders considered in this study was found to be **stress sensitive**.
- MSCR test has shown the potential to **replace Elastic Recovery test**.
- The MSCR test was found to be **faster, more consistent, and easier** to perform when compared to elastic recovery and force ductility.



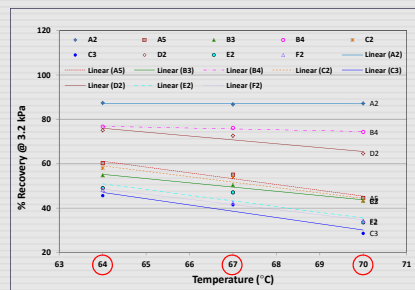
Extended Testing



PG 76-22m: J_{nr} Comparison



PG 76-22m: % Recovery Comparison

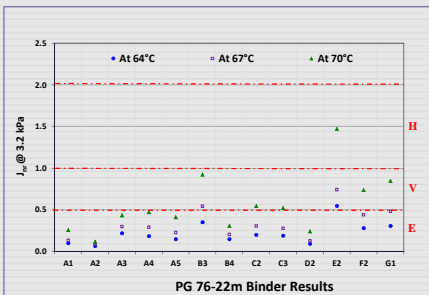


PG 76-22m: J_{nr} Comparison

Temp (°C)	PG 76-22m Binder Samples								
	A2	A5	B3	B4	C2	C3	D2	E2	F2
64	0.0661	0.1490	0.3520	0.1499	0.2011	0.1909	0.0933	0.5489	0.2826
67	0.0860	0.2283	0.5434	0.2044	0.3068	0.2768	0.1289	0.7415	0.4418
70	0.1191	0.4121	0.9241	0.3077	0.5465	0.5235	0.2438	1.4716	0.7378
Avg. of 64°C & 70°C	0.0926	0.2806	0.6381	0.2288	0.3738	0.3572	0.1686	1.0103	0.5102
Avg - 67°C	0.0066	0.0522	0.0947	0.0247	0.0671	0.0804	0.0396	0.2687	0.0684
Ratio (67°C/64°C)	1.30	1.53	1.54	1.36	1.53	1.45	1.38	1.35	1.56
Ratio (67°C/70°C)	0.72	0.55	0.59	0.66	0.56	0.53	0.53	0.50	0.60

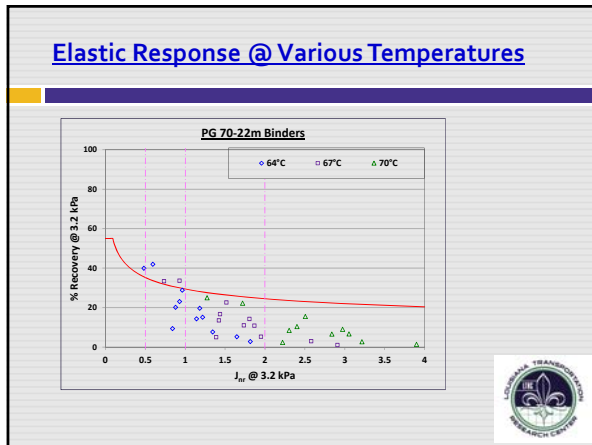
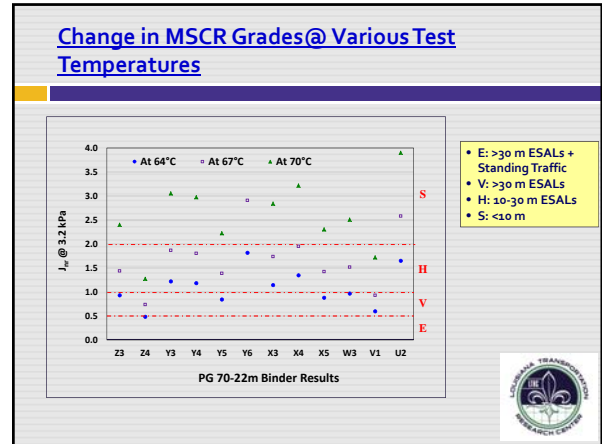
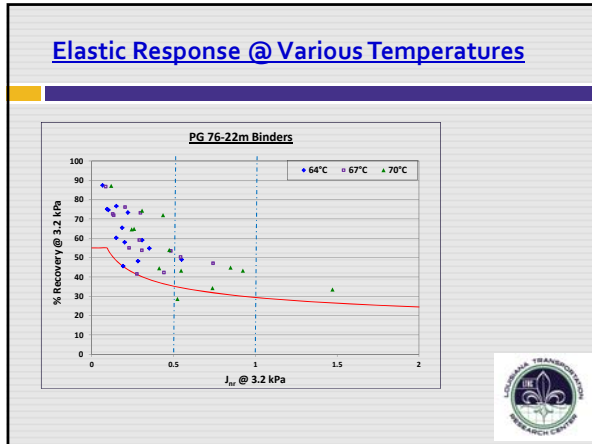


Change in MSCR Grades @ Various Test Temperatures



- H: >30 m ESALs + Standing Traffic
- V: >30 m ESALs
- E: <10 m





Conclusions:

- LADOTD has been recommended to adapt AASHTO MP 19 at 67°C with some limitations.
- It is possible to replace the currently used elastic recovery and force ductility with the MSCR % Recovery criteria.

Conclusions:

- Unaged Original Binders:**
 - PG 76-22m: Keep all current PG test requirements with the exception of replacing Force Ductility ratio with a phase angle of 75° max, tested at 76°C.
 - PG 70-22m: No change with the current PG test requirements.
- RTFO Aged Binders:**
 - PG 76-22m
 - All current PG 76-22m binders have to meet the PG 67-22E criteria as mentioned in AASHTO MP 19.
 - The Elastic response curve (AASHTO TP 70) shall be used to replace the current elastic recovery requirement.
 - PG 70-22m
 - All current PG 70-22m binders have to meet the PG 67-22H criteria as mentioned in AASHTO MP 19.
 - The Elastic response curve (AASHTO TP 70) shall be used to replace the current elastic recovery requirement.

