

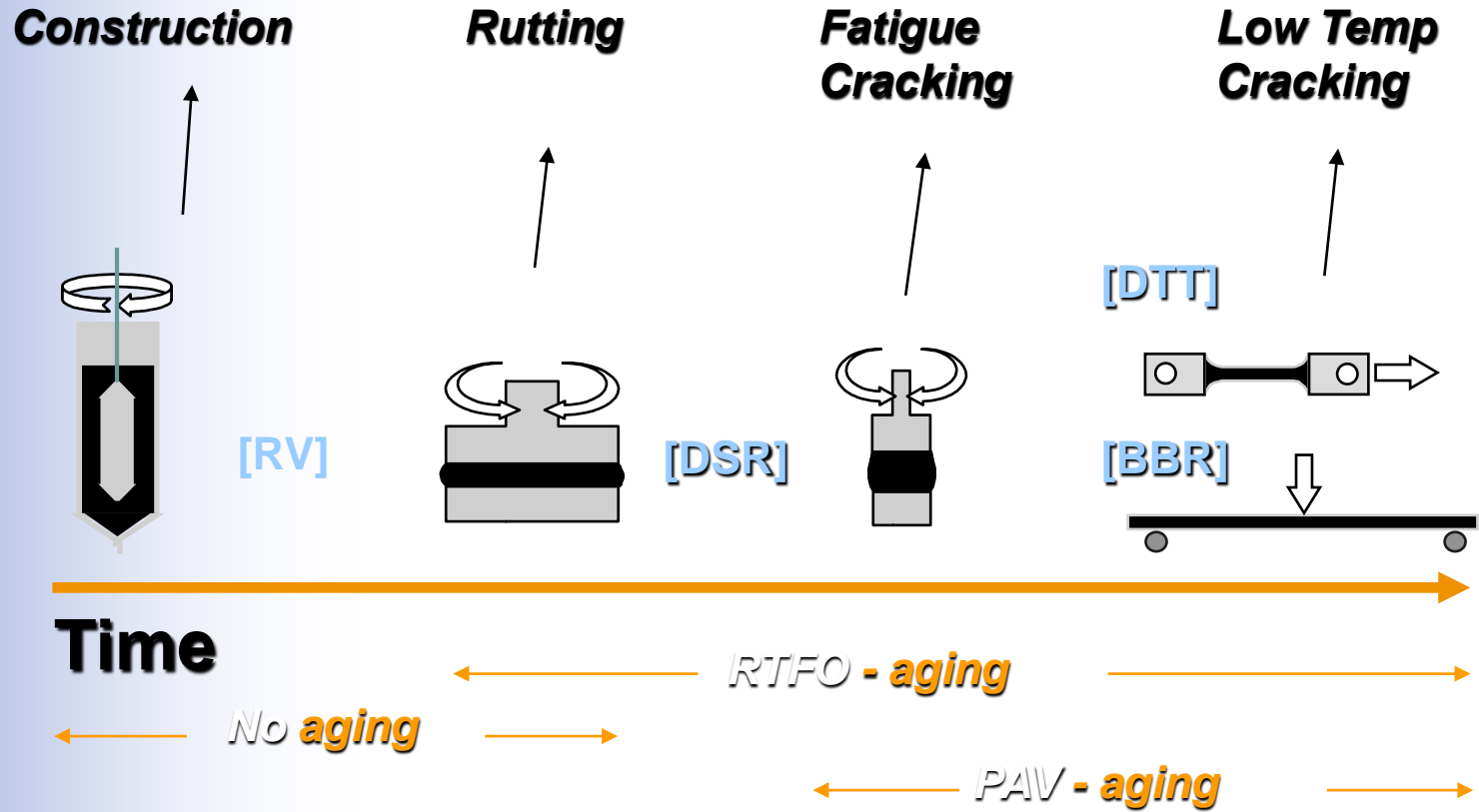
# Asphalt Binders and Aging 20Hr or 40Hr PAV

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# Superpave Binder Specification



# Raveling





# Fatigue Cracking

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# Low Temperature Cracking

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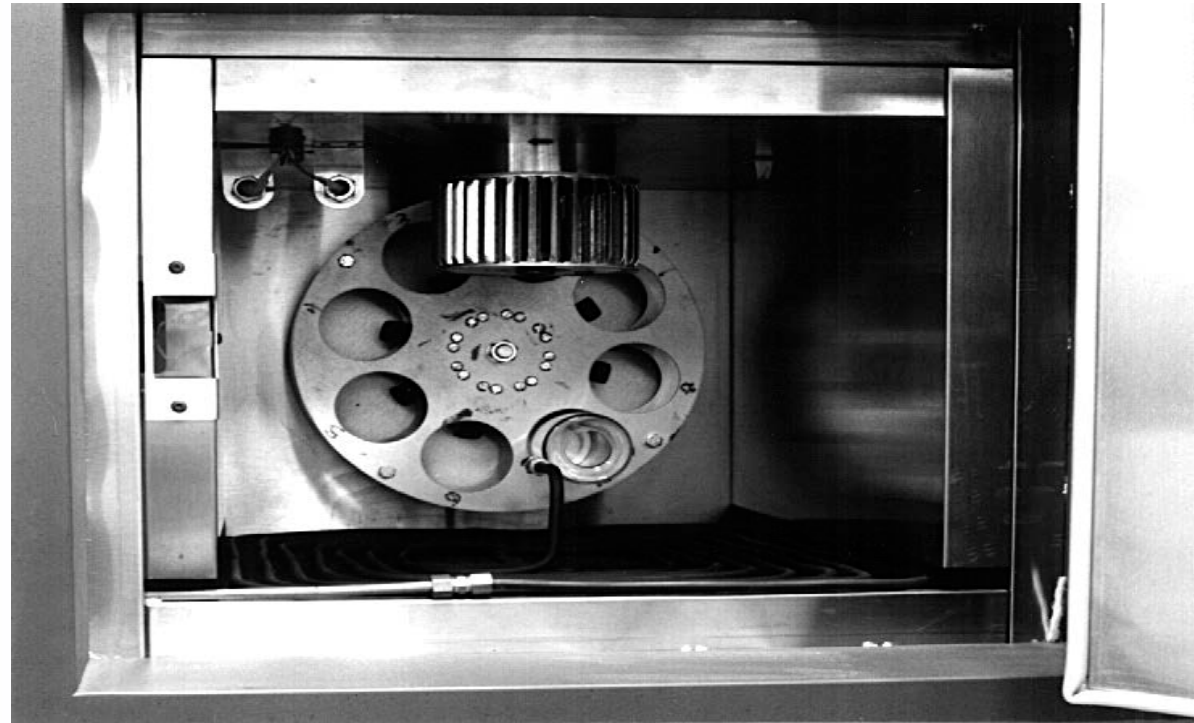


# Superpave Conditioning

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RTFOT –  
Short  
term  
aging



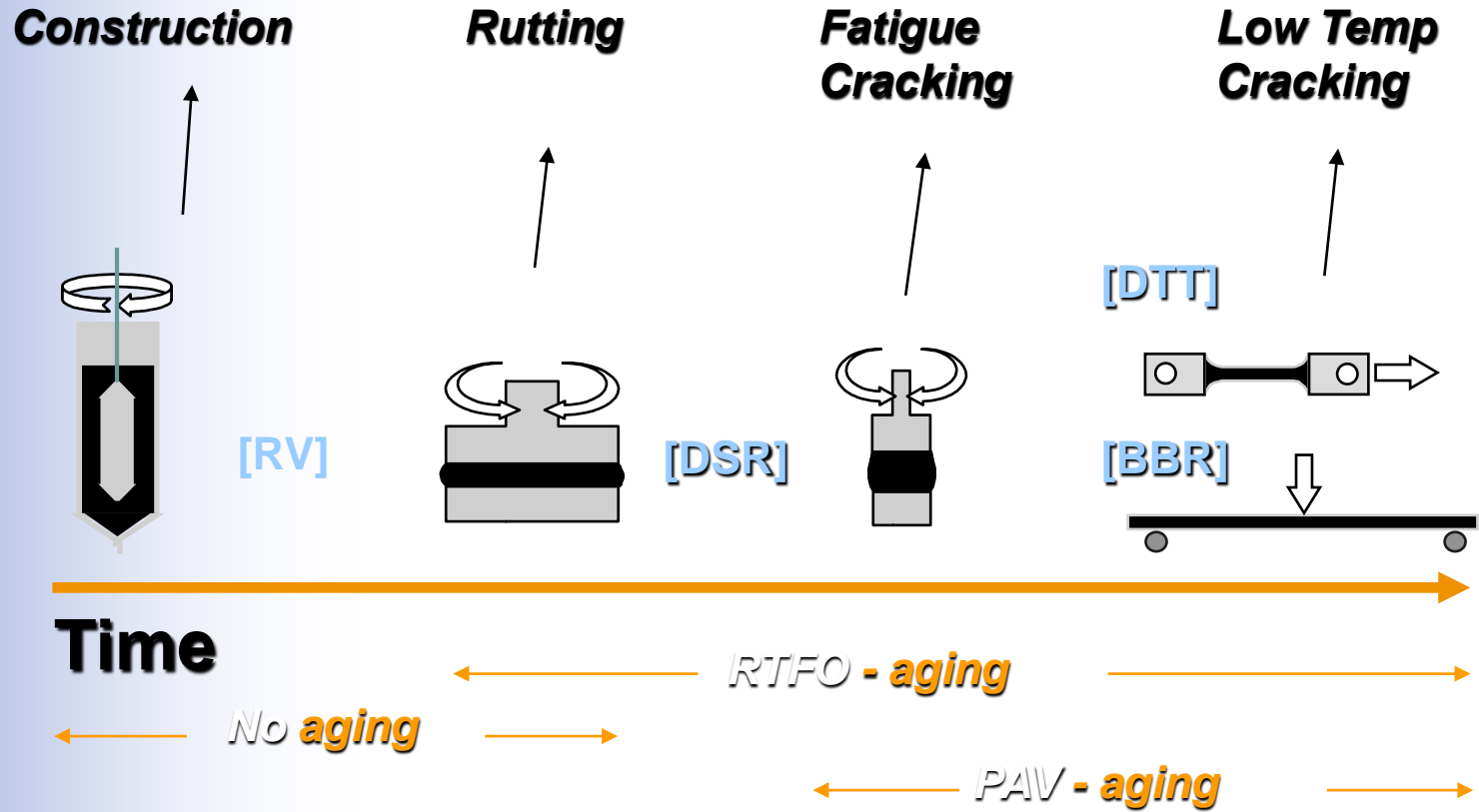


# Aging Long Term

- Current PAV 20 hrs at 100 C, 100 psi.
- 20 hr PAV mandates two days for binder classification.



# Superpave Binder Specification





# Superpave Intermediate Temperature Criteria

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- Existing Criteria  $G^* \sin \delta < 5000 \text{MPa}$  on PAV aged material.
- Criteria is Loss Modulus or Viscos component at intermediate temps.
- Assumption acceptable relaxation will relax stresses and not crack.
- Researchers have been looking for a Fatigue criteria.

So what have we missed?

# There is no Binder Fatigue Criteria

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- Fatigue is a mix cracking issue
  - Structural affects
  - Gradation affects
  - Binder volume affects
  - Binder brittleness – This is the only item that a binder specification can address.

# New Criteria being looked at for Durability and Fatigue

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- $\Delta T_c$  Difference between BBR S failure temp and m failure temp
  - This is intended to capture brittle cracking
- Glover Rowe  $G^*(\cos\delta)^2/\sin\delta$  Original parameter by Charles Glover Texas A&M to capture Ductility at 15°C 0.005 rads/s
- CAM Model R value
  - Defines shape of the master curve indicating if binder has higher  $G^*$  lower  $\delta$ .

# Binder Relaxation Properties

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- Bending Beam Rheometer measures Stiffness and m value.
- BBR m value measures relaxation of the binder at cold temperatures.
- As binder ages the m value continues to decrease indicating loss of relaxation properties while the stiffness increase levels off.
- The difference in temp where  $S = 300\text{MPa}$  and m value = 0.3  $\Delta T_c$  is an indicator of embrittlement.



# Binder Relaxation Properties

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- Ductility
  - Ductility run on unaged or short term aged binders at one temperature does not relate well to cracking.
- Glover TAMU investigated recovered binders for the roadway and correlated ductility at 15°C to cracking.
  - Surrogate property rheological property  $G''/(\eta''/G')$  measured at 15°C 0.005rad/s correlated to ductility.

# Binder Relaxation Properties

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- Rowe recalculated Glover property  $G''/(\eta''/G')$  to  $G^*(\cos\delta)^2/\sin\delta$ . This can be plotted in Black Space.
- Glover TAMU study indicated ductility 5 cm indicates onset of cracking and ductility of 3 cm will exhibit cracking.

# Current Aging approaches

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- Current 20 hour PAV does not represent long enough aging condition to identify critical conditions
  - Extend 20 hour PAV to 40 hour PAV
    - Longer time to grade
  - Use thinner films in the PAV
    - Reduced material for testing
  - Use extremely thin films in an oven.
    - Very small amounts of material special testing 4mm DSR
- There is no Durability or Fatigue Criteria
  - $G^* \sin \delta$  does not correlate well with fatigue or durability

# Aging Influenced By

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- Aggregate Mineralogy
- Aggregate Surface Texture
- Interaction between Asphalt and Aggregate
- Mix Voids
- Temperature – Climate
- Binder Content





# Strange Asphalt PG original, RTFOT

PROPERTY		AASHTO TEST METHOD	SPECS	RESULTS by sample label info below			
				-1	-2	-3	-4
<b>ORIGINAL BINDER</b>							
<b>AASHTO M 320, Table 1 Requirements (DSR's &amp; BBR's reported above and below 'passing')</b>							
Specific Gravity	15.6°C	T 228	Report	1.0146	1.015	1.022	1.018
Flash Point, °C (°F) COC		T 48	230 min.	552 (289)	536 (280)	530 (276)	540 (282)
Viscosity, Pa•s	135°C	T 316	3.0 max.	0.34	0.29	0.375	0.4
Dynamic Shear (G*/sin □) rad./sec.), kPa	58°C	T 315	1.0 min.	--	1.74	--	--
	64°C			1.07	0.826	1.35	1.52
	70°C			0.529	--	0.657	0.74
<b>RTFOT RESIDUE</b>							
<b>AASHTO M 320 Requirements</b>							
Mass Change, % (Mass Loss is reported as Negative)		T 240	1.0 max.	-0.065	-0.17	-0.173	-0.109
Dynamic Shear (G*/sin □) rad./sec.), kPa	58°C	T 315	2.2 min.	--	6.1	--	--
	64°C			4.08	2.91	--	--
	70°C			1.98	1.41	2.62	2.99
	76°C			--	--	1.28	1.46

# Strange Asphalt PG PAV

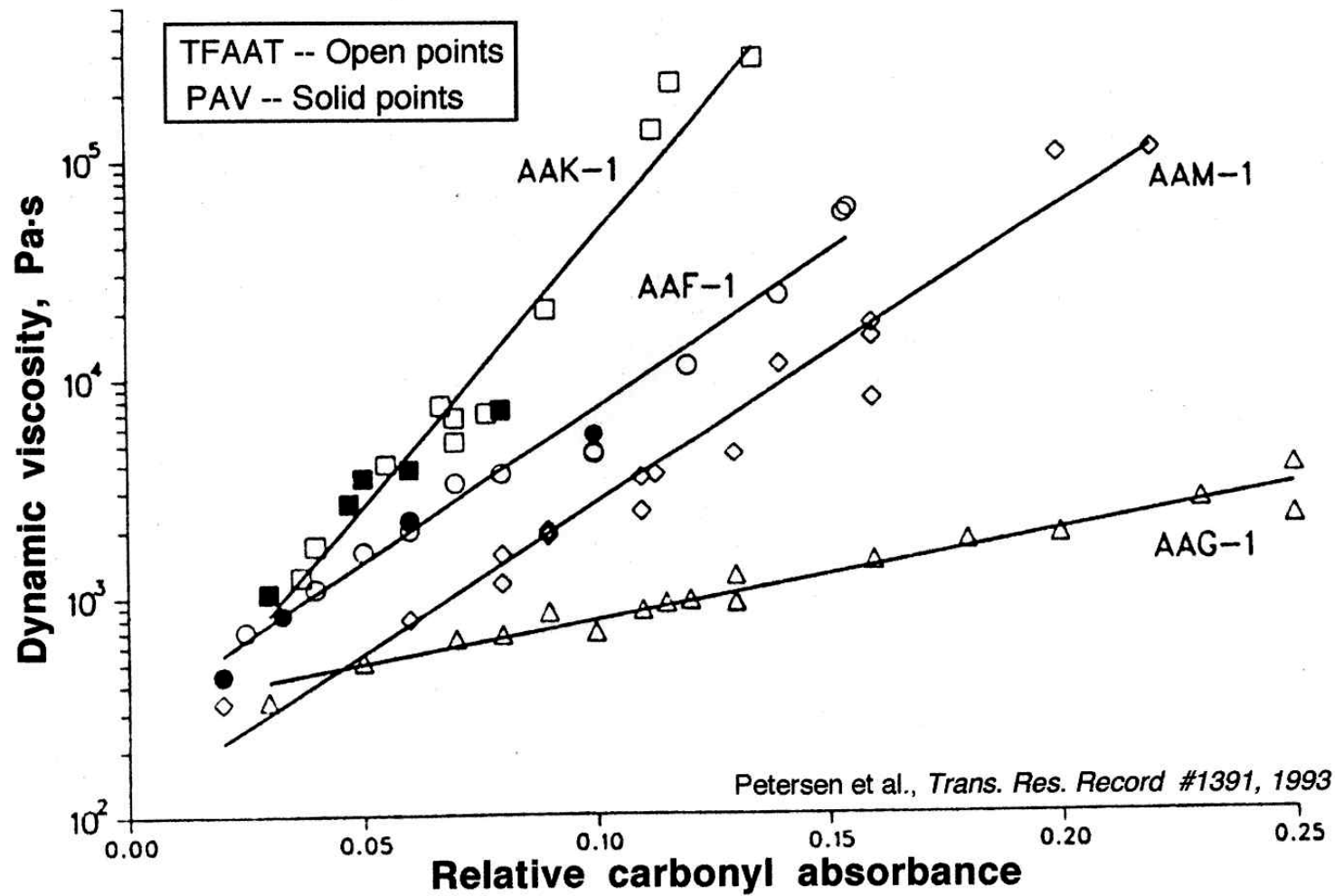
PROPERTY		AASHTO TEST METHOD	SPECS	RESULTS by sample label info below				
				-1	-2	-3	-4	
Dynamic Shear ( $G^* \cdot \sin \delta$ ) rad./sec.), kPa		19°C		4,120	--	4,230	4,480	
				16°C	5,790	4,810	5,940	6,210
				13°C	--	6,760	--	--
Creep Stiffness	Stiffness, MPa (60 sec.)	-12°C	T 313	300 max.	92	--	102	111
	m Value			0.300 min.	0.322	--	0.317	0.352
	Stiffness, MPa (60 sec.)	-18°C		300 max.	191	157	208	197
	m Value			0.300 min.	0.296	0.311	0.29	0.299
	Stiffness, MPa (60 sec.)	-24°C		300 max.	--	312	--	--
	m Value			0.300 min.	--	0.287	--	--
<b>AASHTO M 320 SUPERPAVE™ Binder Grade, PG:</b>				<b>64-22</b>	<b>58-28</b>	<b>64-22</b>	<b>64-22</b>	
<b>AASHTO M320, Table 1, Continuous PG:</b>				<b>64.6-27.1</b>	<b>62.5-30.8</b>	<b>66.5-25.8</b>	<b>67.5-27.9</b>	

# Strange Asphalt

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- Final PG grading UTI looks good all above 90 degrees
- Binders are known to be poor performers in cracking.
- Aging ratio RTFOT/Original close to 4 not 2 like typical asphalts.

# VISCOSITY-CARBONYL RELATIONSHIP DURING PAV AND TFAAT AGING



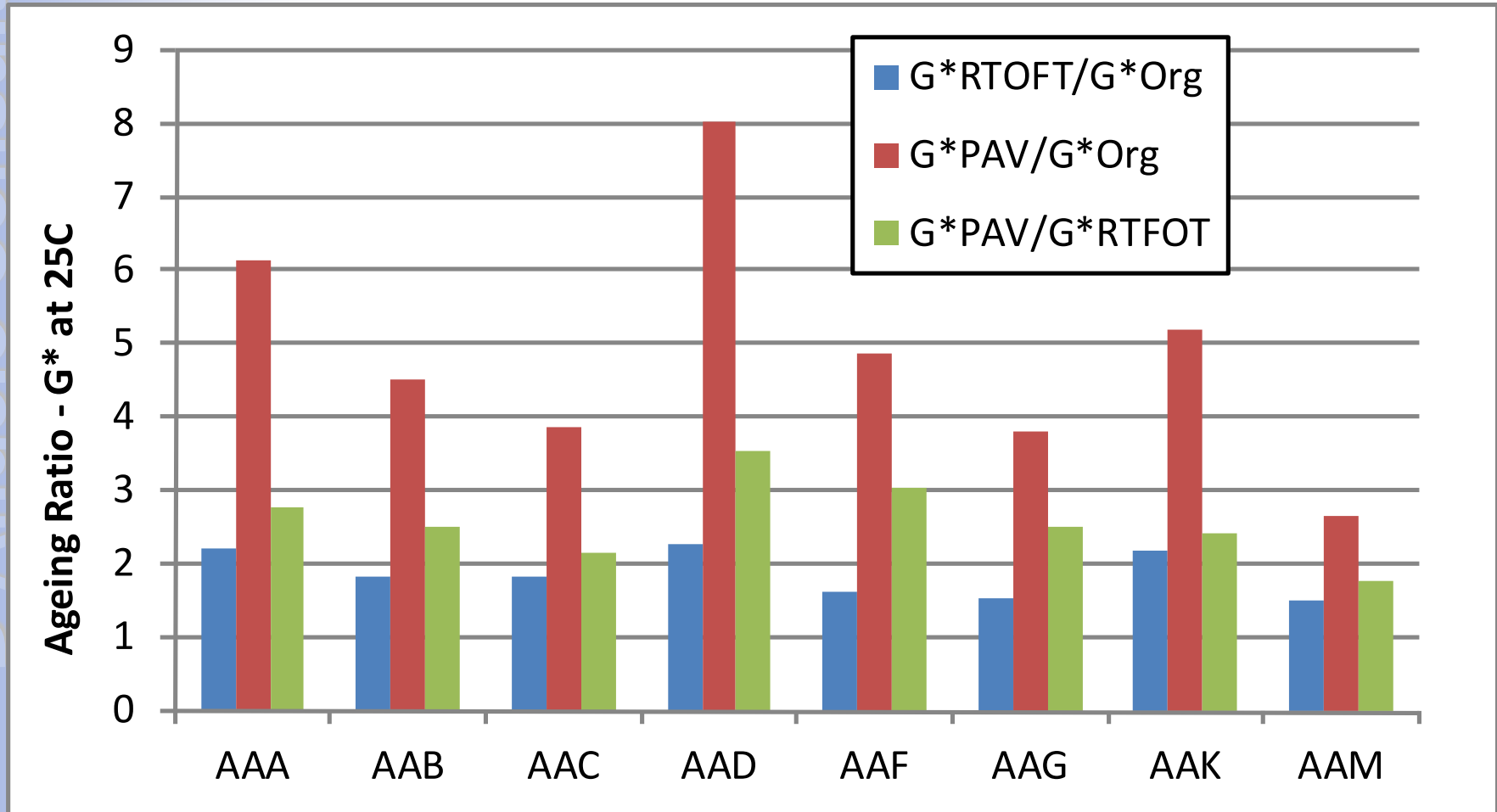


# Binder Aging

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- Longer Aging times being look at to identify embrittlement.
  - Are Longer times needed?
  - Longer time to grade binders
- Can aging ratios identify the same issues?
  - More tests
  - Same time for grading binder

# Aging Ratios for the SHRP Core Asphalts

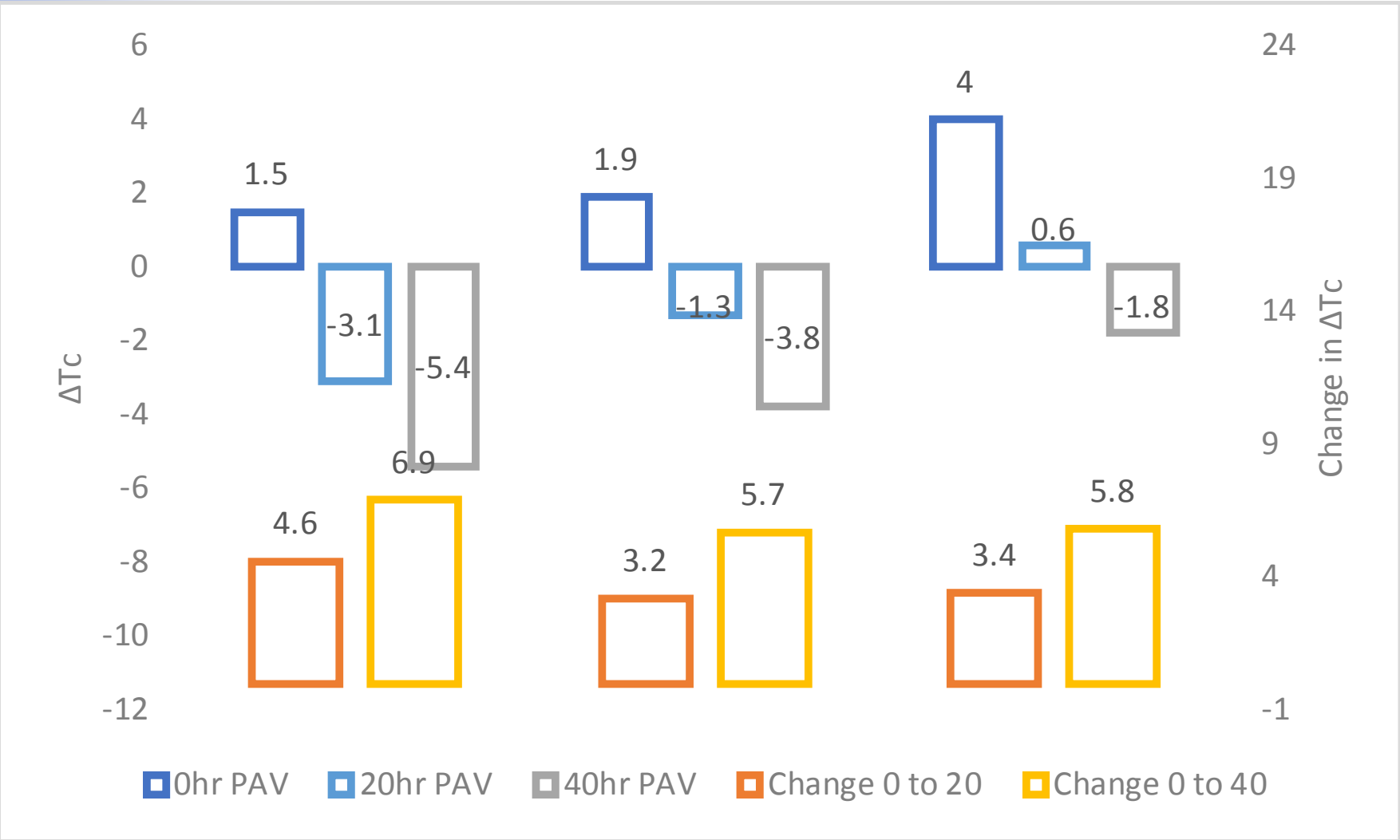


# $\Delta T_c$ 20 and 40 hour PAV

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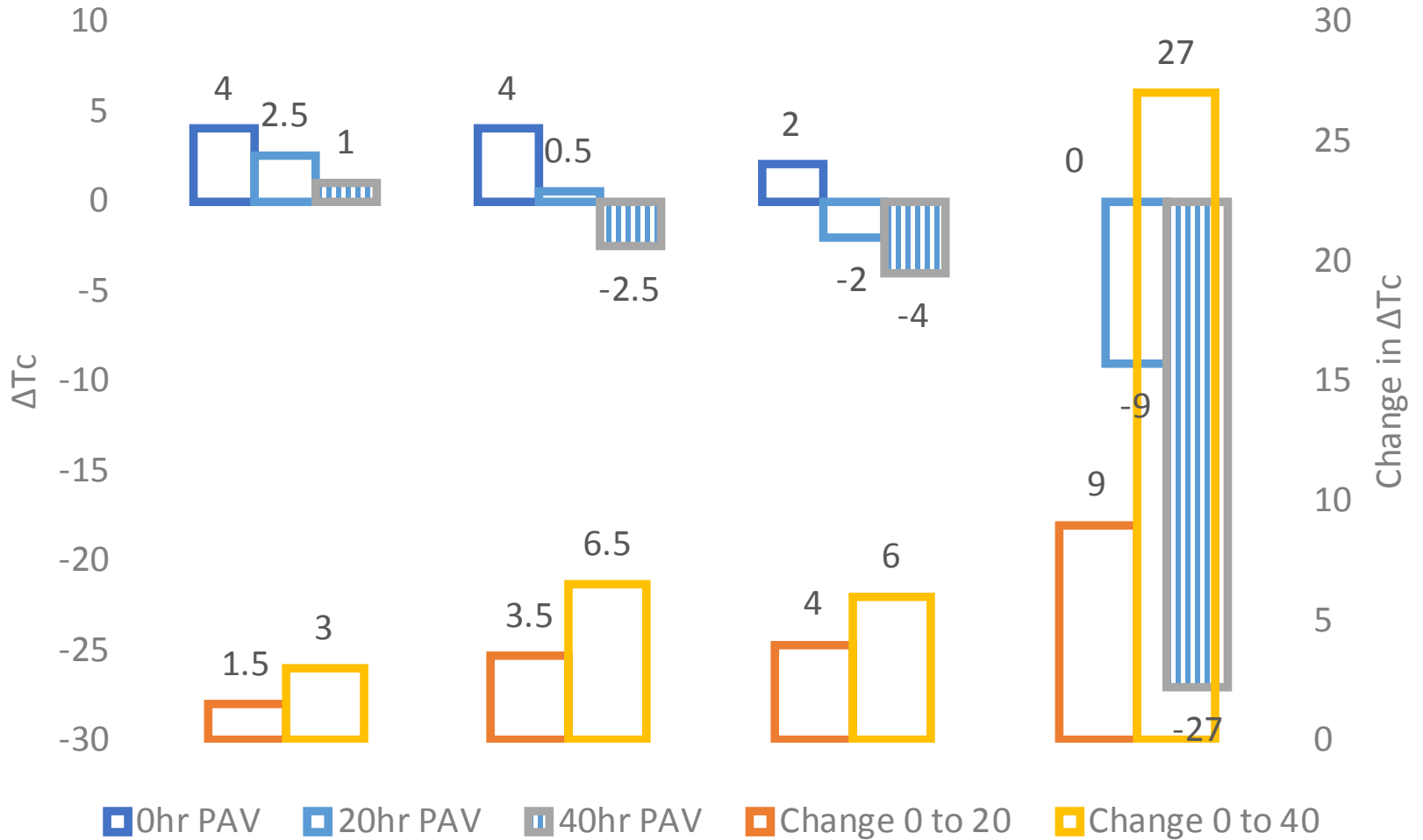
- Can we determine where the 40hr PAV value we go based on the 20hr PAV?
- Look at the 20hr value and the change from original to 20hr.

# Anderson Data AAPT

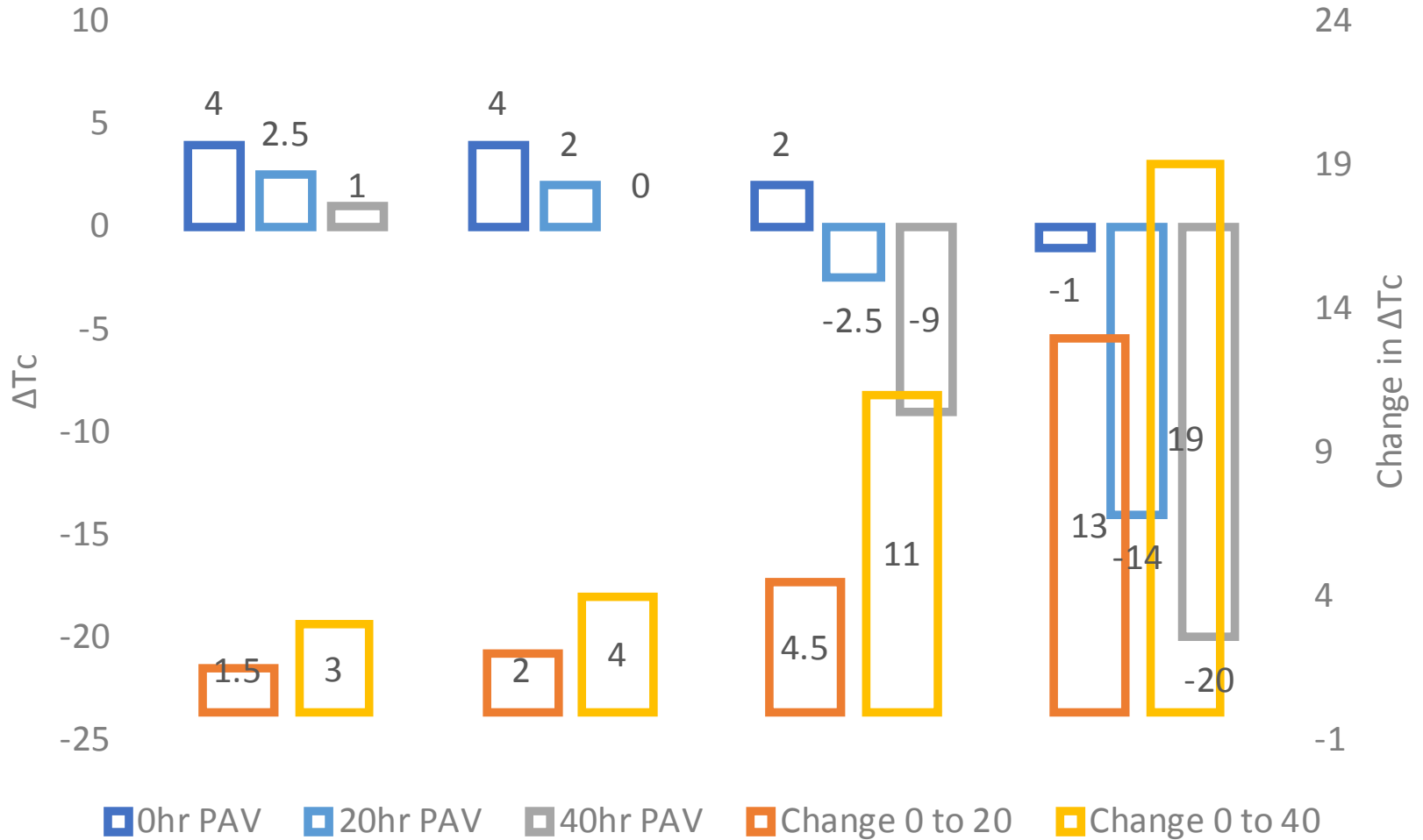




# Bennert AAPT Source 1



# Bennert AAPT Data Source 2

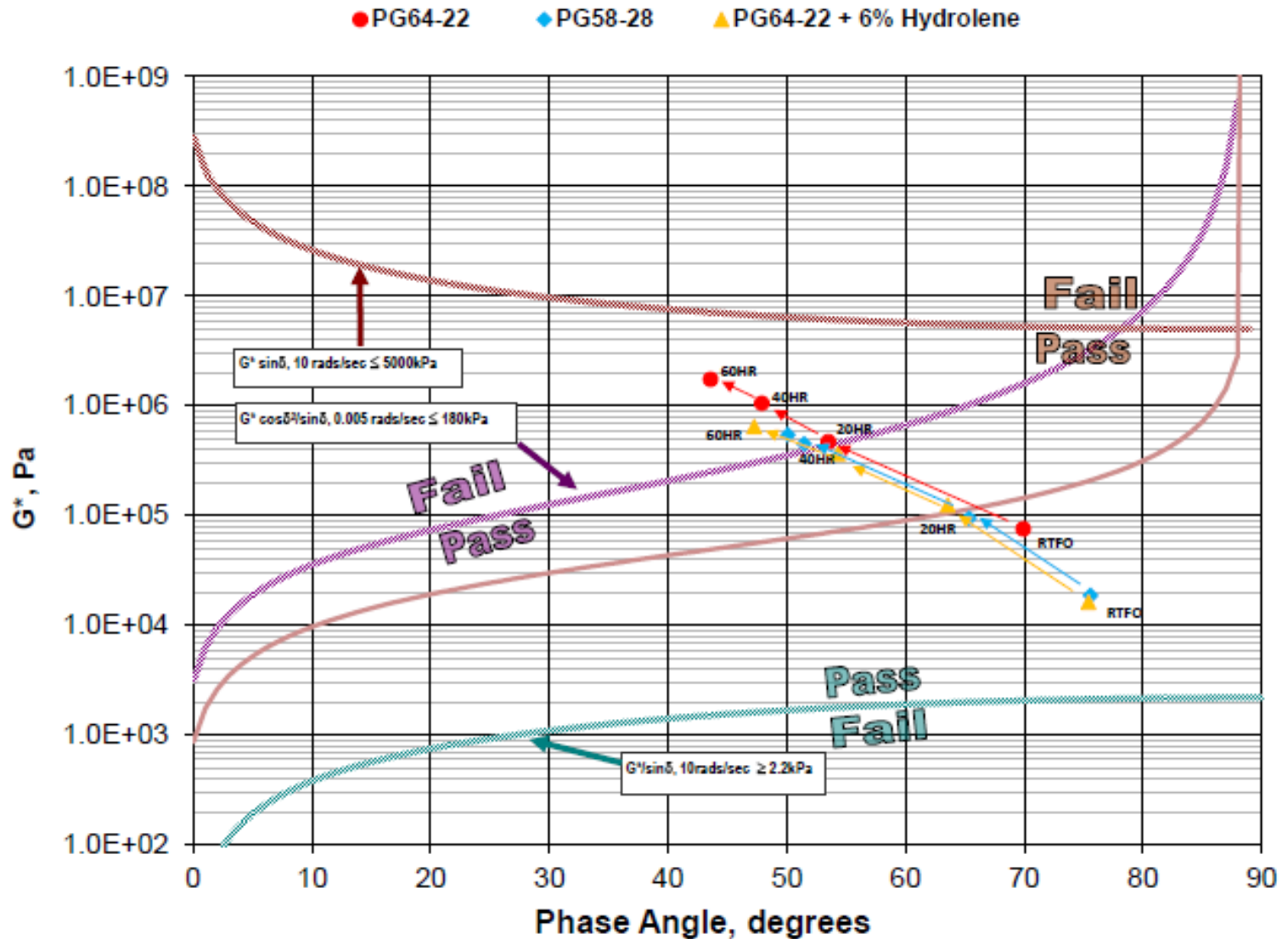


# $\Delta T_c$

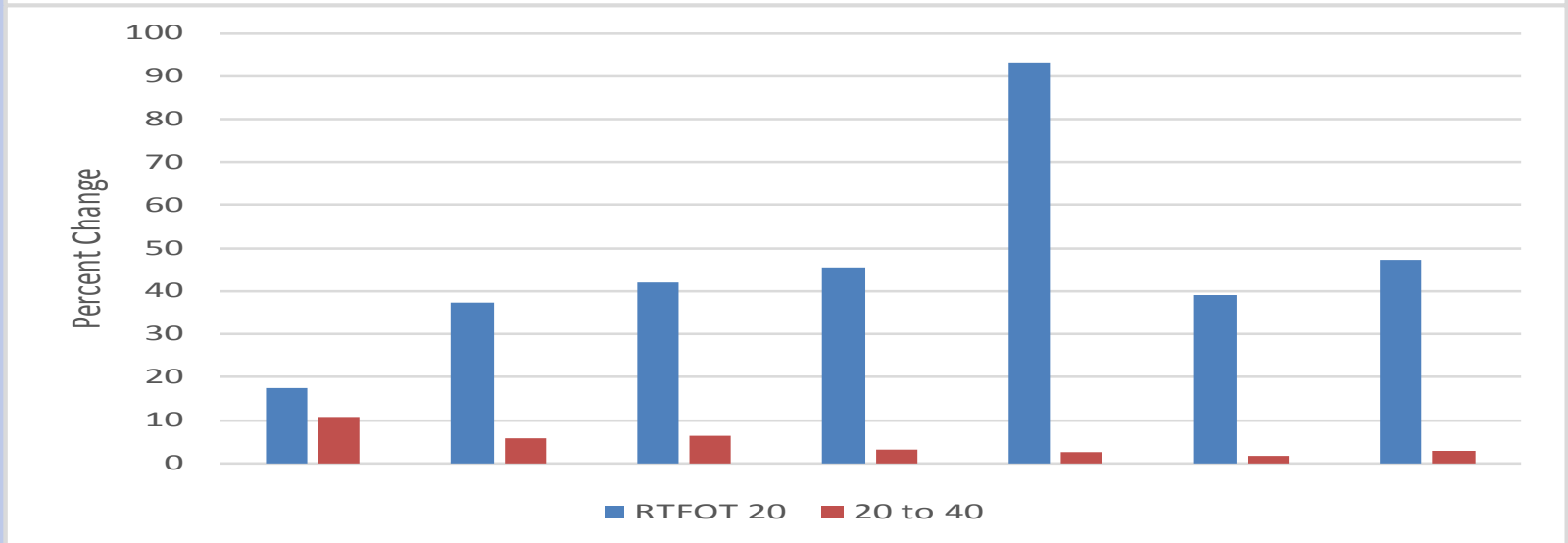
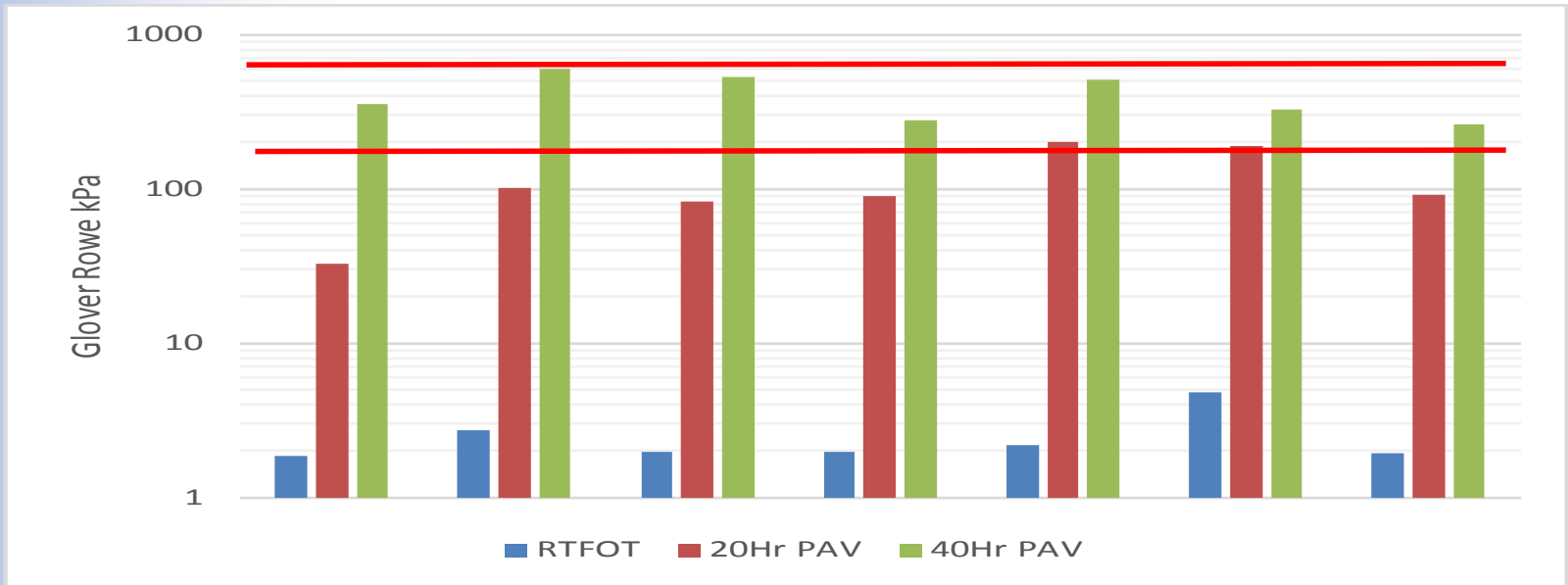
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- There are clear indications that the 20hr PAV and the change from original provides clear indications if 40 hr PAV will fail.

# Black Space plot of Glover Rowe parameter.

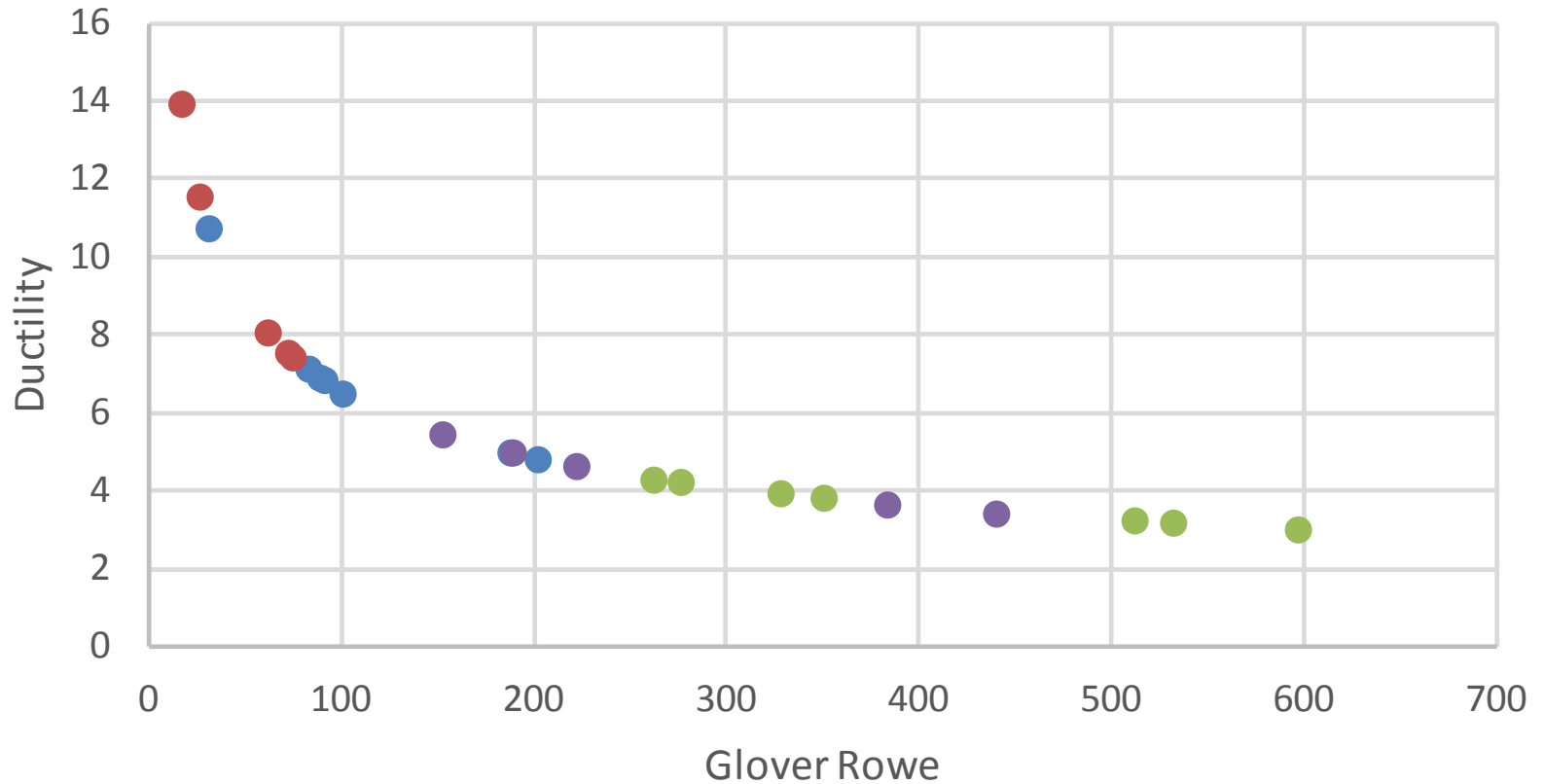


# Mogawer AAPT





# Glover Rowe 12 AC's 58-28, 64-28.



● 64-28 20hr PAV ● 54-28 20hr PAV ● 64-28 420hr PAV ● 58-28 40hr PAV

# Asphalt Binder Aging

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- There can be no Binder Fatigue Criteria
- Need to capture embrittlement
- The current criteria does not capture embrittlement
- New Criteria evaluating embrittlement
- Are longer aging times needed?
- Binder aging ratios may capture the same issues without longer aging times.

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**Thank You**

**Discussions**