Asphalt Institute TAC Evaluation of New PG Specifications

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Charleston, WV
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Objectives of Task Force

1. Understand recent NCHRP recommendations.
2. Evaluate alternatives from literature.
3. Quantify variability.
4. Assess proposed threshold values and interrelationships.
5. Outreach
   - Final Report
   - AASHTO COMP
   - Regional User-Producer Groups (NCAUPG and SEAUPG in 2025)
   - AMAP

Round Robin Study

Materials

Sample ID	AASHTO M320/M332 Grade	M320/M332 IT Test Temp, °C	NCHRP 9-59 IT Test Temp, °C
A	PG 52-28	16	22 (+6)
B	PG 64-22	25	25
C	PG 64-22	25	25
D	PG 64-22	25	25
E	PG 70-22	28	25 (-3)
F	**PG 58V-34**	**16**	**19 (+3)**
G	PG 64S-22	25	25
H	**PG 76E-28**	**28**	**22 (-6)**

Polymer Modified Asphalt

- 15 Labs (only 4 for ABCD)
- 6 Suppliers
- Blind samples:
  - Collected and distributed by Asphalt Institute.
- Standardized data collection form sent to all labs.

Test Methods

Standard	Test	Additional Instructions
AASHTO T240	Rolling Thin-Film Oven (RTFO) Conditioning	None
AASHTO R28	Pressurized Aging Vessel (PAV) Conditioning, 20- and 40-hours cycles	• PAV Temperature selected based on AASHTO M320/M332. • 40-hr PAV in one continuous cycle.
AASHTO T315	Dynamic Shear Rheometer (DSR) Testing	• Silicon mold or direct pour allowed. • Prescribed 8mm test temperatures by sample in instructions.
AASHTO T313	Bending Beam Rheometer (BBR) Testing	• Vacuum degassing of PAV residue required. • Follow R118 for ΔT_c determination.
AASHTO T387	Asphalt Binder Cracking Device (ABCD) Testing	• Cooling rate modified. From 20°C to 0°C = 20°C/hr. From 0°C to -60°C = 10°C/hr.

Parameters Studied

Parameter	Type	Testing Requirements	Reference
G*sinδ	Point	Current Practice	M320/M332
GRP and log GRP	Point	T315 at 9-59 Int. Temp	NCHRP 9-59
R-Value (BBR)	Shape	T313 at Low test temp.	NCHRP 9-59
R-Value (DSR)	Shape	T315 at 9-59 Int. Temp	WHRP
ΔT_c	Shape	R118	NCHRP 9-60
δ at G*=8967 or 10 MPa	Shape	T315 multiple temps	CTAA
δ Difference	Polymer Identification	δ at 64°C δ at constant G*	D'Angelo/Bennert
ΔT_f	Failure	T387 (modified)	NCHRP 9-60

- Lack of consensus on shape parameters, many different ideas.
- δ Difference used with δ at Constant G* for PMAC.

Approaches Investigated

1. NCHRP 9-60
   - ΔT_c (BBR – R118) and ΔT_f (ABCD – T387)
2. NCHRP 9-59
   - GRP at 9-59 IT (T315 – Point Parameter), R-Value at LT (T313 – Shape Parameter)
3. Hybrid Approach
   - GRP at 9-59 IT (T315 – Point Parameter), δ at G*=10MPa (T315 – Shape Parameter)

Results

Sample	Aging	NCHRP 9-60		NCHRP 9-59		Phase Angle + GRP	
		ΔT_c, °C	ΔT_f, °C	R-Value	GRP, kPa	Phase at G* = 10 MPa, °	GRP, kPa
Limits	PAV 20	-2, -6	7,10	1.5-2.5	5000	42	5000
	PAV 40	-3, -7	3,6	2.0-3.2	8000	38	8000
A, PG 52-28	PAV 20	PASS	N/A	PASS	PASS	PASS	PASS
	PAV 40	PASS	N/A	PASS	PASS	PASS	PASS
B, PG 64-22	PAV 20	PASS	N/A	PASS	PASS	PASS	PASS
	PAV 40	PASS	N/A	FAIL	PASS	PASS	PASS
C, PG 64-22	PAV 20	ABCD Required	FAIL	PASS	PASS	FAIL	PASS
	PAV 40	FAIL	N/A	PASS	FAIL	FAIL	FAIL
D, PG 64-22	PAV 20	ABCD Required	FAIL	PASS	PASS	FAIL	PASS
	PAV 40	FAIL	N/A	PASS	FAIL	FAIL	FAIL
E, PG 70-22	PAV 20	ABCD Required	FAIL	PASS	PASS	FAIL	PASS
	PAV 40	ABCD Required	FAIL	PASS	FAIL	FAIL	FAIL
F, PG 58V-34	PAV 20	PASS	N/A	PASS	PASS	FAIL	PASS
	PAV 40	PASS	N/A	PASS	PASS	FAIL	PASS
G, PG 64-22	PAV 20	PASS	N/A	PASS	PASS	PASS	PASS
	PAV 40	PASS	N/A	PASS	PASS	PASS	PASS
H, PG 76E-28	PAV 20	ABCD Required	PASS	PASS	PASS	FAIL	PASS
	PAV 40	ABCD Required	PASS	PASS	PASS	FAIL	PASS

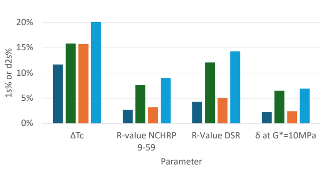
Analysis

Introduction

- Outcomes vary by approach, particularly for shape parameters.
  - NCHRP 9-59 R value was least sensitive. One sample failed because it was too low. (High R Value = Poor relaxation).
  - δ at G*=10 Mpa flagged a majority of samples (10/16), ΔT_c flagged 8/16 samples.
- Challenges Identified
  - Variability of specific parameters.
  - Polymer modification.
  - Reconciling limits.
  - Intermediate test temperature selection.

Challenge #1, ΔT_C Variability

Aging	δ at G*=10 MPa, °		R Value (NCHRP 9-59)		R Value (DSR)		ΔT_c, °C	
	1s%	d2s%	1s%	d2s%	1s%	d2s%	1s	d2s
PAV 20	2.3%	6.5%	2.7%	7.6%	4.3%	12.1%	0.7	1.9
PAV 40	2.4%	6.9%	3.2%	9.0%	5.1%	14.3%	1.1	3.1



- Chart reflects variability at NCHRP 9-60 ΔT_c Limits (-6°C/-7°C).
- ΔT_c has highest variability and is most time consuming.
- Other shape parameters provide similar information.

Challenge #2
ABCD Test

- Total Test Time = 7 hours.
  - Cooling rate used in study was 20°C/hr from 20°C to 0°C + 10°C/hr from 0°C to -60°C.
- Commercially available machine has a chamber that can hold 16 specimens.
- Not commonly available in commercial labs.
  - 4/15 AI RR Labs were able to run the test.
- Research Tool vs. Product Certification

Figure 4—Silicone Mold–ABCD Ring Assembly

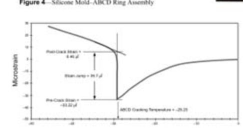
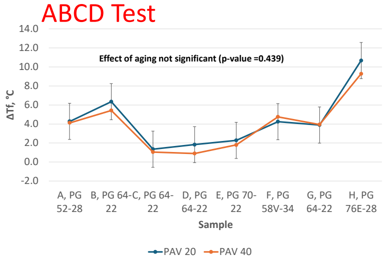


Figure 6—Typical ABCD Test Results: Strain versus Temperature

Taken from AASHTO T387

Challenge #2
ABCD Test



Error bars are the 1s (PAV 20) from the AI RR study.

Tukey Test at α = 95% - PAV 20 and PAV 40

Factor	N	Mean	Grouping		
H	4	10.52	A		
B	4	6.35	A	B	
A	4	4.275		B	C
F	4	4.25		B	C
G	4	3.900		B	C
E	4	2.275		B	C
D	3	1.833		B	C
C	4	1.350			C

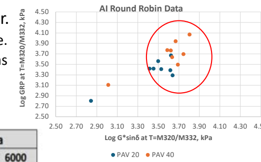
Means that do not share a letter are significantly different.

Factor	N	Mean	Grouping	
H	4	9.28	A	
B	4	5.42	A	B
F	4	4.750	A	B
A	4	4.125	A	B
G	4	3.95	A	B
E	4	1.80		B
C	4	1.05		B
D	3	0.90		B

Means that do not share a letter are significantly different.

Challenge #3 Glover Rowe Parameter - Benefits

- Replacing G*sinδ with the Glover Rowe Parameter.
  - Reduces risk of accepting binders with low phase angle.
  - Improved relationship to lab and field performance was observed (NCHRP 9-59, Bennert WHRP).



G* (kPa)/δ (degrees)	GRP, kPa			G*sin δ, kPa		
	8000	7000	6000	8000	7000	6000
40	7303	6391	5478	5142	4500	3857
42	6603	5777	4952	5353	4684	4015
45	5657	4950	4243	5657	4950	4243
47	5088	4452	3816	5851	5119	4388
50	4315	3776	3236	6128	5362	4596

Anderson, 2022

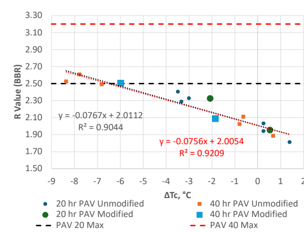
- Parameters are unrelated.
- Same test temperature (M320/M332).
- For log G*sinδ = 3.7 kPa (5000 kPa), log GRP varies from 3.3 kPa (2000 kPa) to 3.9 kPa (8000 kPa).

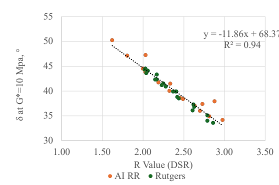
Challenge #3 Glover Rowe Parameter - Risks

Parameter	Aging	Spec. Limit	1s%	Adj. Spec. Limit	d2s%	Acceptance Limit
G*sinδ, kPa, max	PAV 20	6000	**9.8%**	N/A	**27.3%**	6800
	PAV 40	N/A	**10.0%**	N/A	**28.1%**	N/A
GRP, kPa, max	PAV 20	5000	**14.5%**	5700	**40.5%**	6900
	PAV 40	8000	**19.6%**	9600	**54.9%**	12,100
Log GRP, kPa, max	PAV 20	3.7	**1.9%**	3.8	**5.3%**	3.9
	PAV 40	3.9	**2.3%**	4.0	**6.4%**	4.1

- GRP will have higher variability than G*sinδ.
- GRP linear vs. Log Scale
  - Maximum limit placed on GRP.
  - Variability of GRP scales with result. Higher GRP = More variability.
  - Log basis reduces scaling effect with increasing GRP.

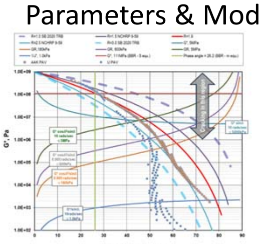
Challenge #4: Relationships Between Parameters & Effects of Modification

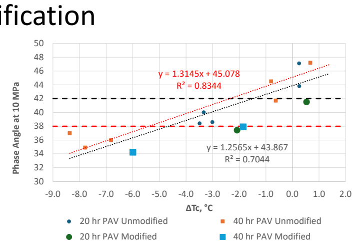




When shape parameters are evaluated in the same stiffness range, good relationship observed for modified and unmodified binders.

Challenge #4 Relationships Between Parameters & Modification

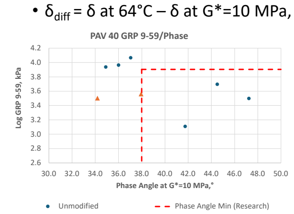


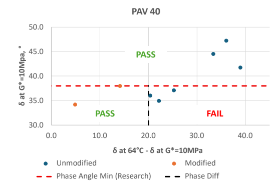


When shape parameters are evaluated in the different stiffness range, offset for modified binders. “Feathering” of master curve at intermediate temperatures.

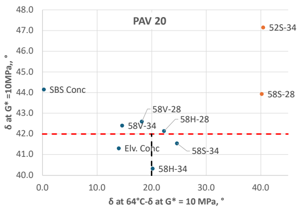
Challenge #4: Application of δdiff for Polymer Modification

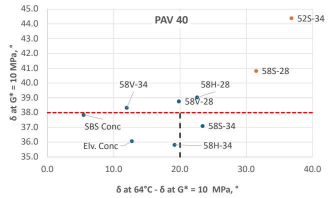
- δ_{diff} = δ at 64°C – δ at G*=10 MPa, modified asphalts will have lower δ_{diff}





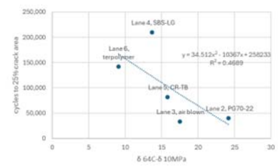
Challenge #4: Application of δdiff - MIA Terminal



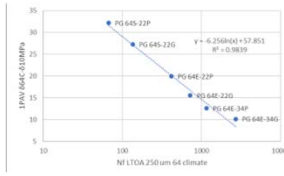


- Max Limit on δ_{diff} may require adjustment.
- Differentiation between unmodified base binders and PMAC.

Challenge #4
δ_{diff} Relation to Performance



2002 FHWA ALF Data (D'Angelo email correspondence)



Phase Angle diff vs. Bending Beam Fatigue D'Angelo, Baumgardner, 2025

Challenge #4: Reconciling Limits

- Parameters are related, but produced different spec. outcomes using current limits.
- Tables show estimated shape parameters for different ΔT_c values.
- Adjusted Failure Limits:
  - NCHRP R-Value
    - 2.5 (PAV 20), 2.7 (PAV 40)
  - δ at G*=10 Mpa
    - 38° (PAV 20), 36° (PAV 40)

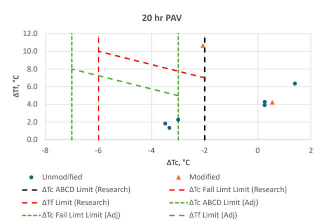
ΔTc vs. R-Value NCHRP 9-59

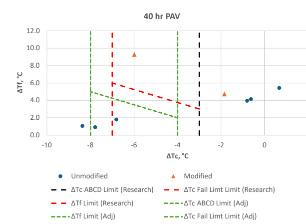
Aging	Type	ΔT_c Limit, min, ° C	Est. R-Value (NCHRP 9-59)	NCHRP 9-59 Spec.
PAV 20	ABCD	-2	2.18	1.5-**2.5**
PAV 20	**Failure**	**-6**	**2.52**	
PAV 40	ABCD	-3	2.26	2.0-**3.2**
PAV 40	**Failure**	**-7**	**2.61**	

ΔTc vs. Other Shape Parameters

Shape Parameter	Slope (m)	y-int	R^2, %	ΔT_c, ° C			
				-2	**-3**	**-6**	**-7**
R-Value (NCHRP 9-59)	-0.076	2.005	92.1	2.16	2.23	**2.46**	**2.54**
R-Value (DSR)	-0.100	2.002	86.2	2.20	2.30	**2.60**	**2.70**
δ at G*=10 MPa, °	1.315	45.08	83.4	42.5	41.1	**37.2**	**35.9**

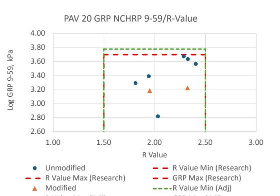
Performance Space Diagrams - NCHRP 9-60

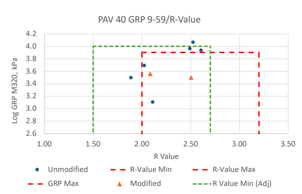




Adjusted limits based on observed variability of ΔT_c and ΔT_f. Adjustments for demonstration and not considered final.

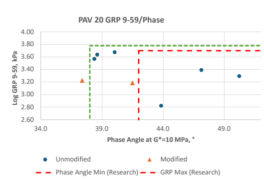
Performance Space Diagrams - NCHRP 9-59

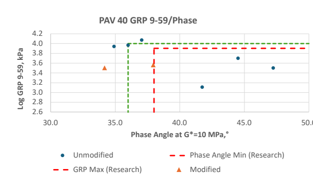




- GRP limit adjusted to account for test variability.
- R value adjusted to better match ΔT_c. Lower limit for PAV 40 expanded to match PAV 20.

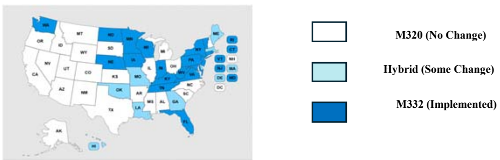
Performance Space Diagrams - GRP and δ at G* = 10 MPa





- GRP Adjusted for Variability. Phase Angle adjusted to match ΔT_c.
- Unmodified asphalts with low phase angle had high GRP. Use of δ_{diff} may allow for higher phase angle limit.

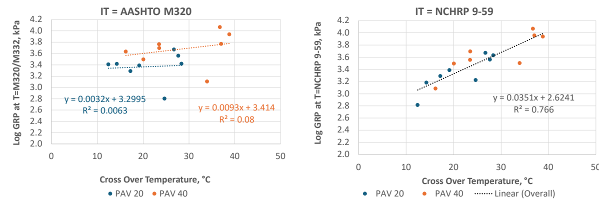
Challenge #5: Intermediate Test Temperature Selection



US State Binder Specifications - Asphalt Institute

- M332 has not been implemented by all states. Currently have two different IT Temperatures in specification.
- NCHRP 9-59 recommends basing IT on only LT PG, implementation could cause three different test temperatures for the same product.

Challenge #5
Which Intermediate Temperature is Correct?



- Limited data set. 4/8 samples were PG 64-22 and had same test temperature.
- Cross Over Temperature = Temp where $\delta = 45°$

Recommendations and Discussion

Primary Recommendation

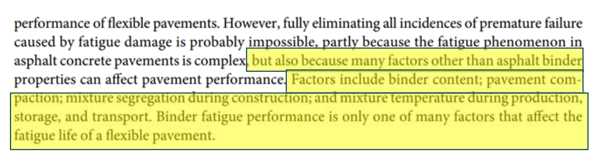
- No changes to current specifications.
  - NCHRP 9-60 is not complete.
  - NCHRP 9-59 acknowledged limits are tentative.
  - Applying proposed limits results in different pass/fail outcomes.
  - Limits for polymer modification require review.
- Final specification requirements.
  - Include a point and shape parameter.
  - Consistency in IT Test Temperature selection.
  - Address polymer modification.
- Asphalt Institute TAC Forming Task Force to evaluate Specification Version 2.0

Future Research and Implementation

- ASTM WK94248 – Possible TFASH Item
  - Procedure for many of the shape parameters discussed.
- Quantify variability of GRP. AASHTO PSP? Other Round Robins?
- Prioritize shape parameters to focus future research.
  - Results may differ based on stiffness range. Discussion on which is correct.
  - Address polymer modification. Phase angle difference?
- Evaluation of the ABCD Test. Is it viable?
  - Variable and time consuming. AI RR data was insensitive to aging.
  - More labs needed.
- Use of 40-hour PAV in specifications.

Goals and Expectations of New Binder Specification

Excerpt from 9-59 Report


performance of flexible pavements. However, fully eliminating all incidences of premature failure caused by fatigue damage is probably impossible, partly because the fatigue phenomenon in asphalt concrete pavements is complex but also because many factors other than asphalt binder properties can affect pavement performance. Factors include binder content; pavement compaction; mixture segregation during construction; and mixture temperature during production, storage, and transport. Binder fatigue performance is only one of many factors that affect the fatigue life of a flexible pavement.

Open Discussion
TRB 2025 Workshop Recap

Scope of changes is much greater than the MSCR test and similar to SHRP Program.

- SHRP Implementation
  - Significant Problem.
  - Consensus solution.
  - Significant long-term funding for research, education, training.
- NCHRP Project
  - Is there a significant problem?
  - Different solutions: NCHRP, other research, state agency adoption.
  - One time funding, no education/training programs in place.

Thank You!

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