Industry Approach to Evaluate New PG Specifications

Southeast Asphalt User Producer Group Meeting
Little Rock, AR

November 14, 2023

Andrew Hanz, PhD, PE
Mathy Construction

Case Study - MSCR Test

Research to Standards and Specification

1996-2001
NCHRP 9-10

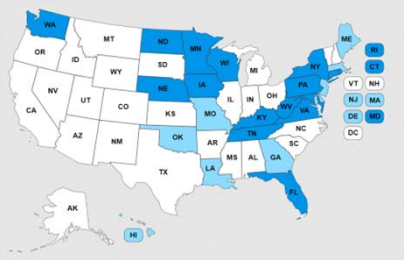
2007
AASHTO TP-70

2010
AASHTO MP-19

2014
AASHTO T350 and M332

Case Study – MSCR Test

State Agency Implementation (2022)



M320 (No Change)

Hybrid (Some Change)

M332 (Implemented)

https://www.asphaltinstitute.org/engineering/specification-databases/us-state-binder-specifications/

Case Study – MSCR Test

- FHWA Champion for Test Methods and Specification
  - John D'Angelo. Also topic of Ph.D. Dissertation
- Agency/Industry Partnership
  - Actively discussed at Binder ETG and User/Producer Groups
- AASHTO Approval
  - Transitioned from provisional standard to full standard.
  - Process from research to full standard ~18 years.
- State Adoption
  - Less than 50%

NCHRP Projects and Status

1. NCHRP 9-59: Relating Asphalt Binder Fatigue Properties to Asphalt Mixture Fatigue Performance
   - Complete (6/30/2019)
   - **$1,000,000**
2. NCHRP 9-60: Addressing Impacts of Changes in Asphalt Binder Formulation and Manufacture on Pavement Performance through changes in Specifications.
   - **Active (4/30/2024)**
   - **$1,150,000**
3. NCHRP 9-61: Short & Long-term Binder Aging Methods to Accurately Reflect Aging in Asphalt Mixtures
   - Complete (3/31/2021)
   - **$750,000**

Overview of Research Projects

Goal

Improve durability and cracking resistance of asphalt binders.

Approach

1. Replace Fatigue Parameter ($G^*\sin\delta$)
2. Add Relaxation Parameter (R-value, ΔT_c, ΔT_f)
3. Extended Aging – 20 hour PAV and 40 hour PAV

What Could A New Specification Look Like?

PAV Aging Temperature (°C)	100						100 (110)					
Dynamic Shear, T315 G*(cos δ)²/sin δ², 10 rad/s, at intermediate temp [a] > 5,000 kPa (>8,000 kPa)	29	27	25	22	19	17	29	27	25	22	19	17
Creep Stiffness, T313 Stiffness < 300 Mpa m-value > 0.300 at 60 sec & low temp	0	-6	-12	-18	-24	-30	0	-6	-12	-18	-24	-30
Creep Stiffness, T313 R=log(2)log(S/3000)/log(1-m) at 60 sec & low temp min < R < max	1.50 < R < 2.50						1.50 < R < 3.20					
ΔTc Tc,S - Tc,m	≥ -2.0 [b]						≥ -3.0 [c]					
ΔTf [b] Tc,S - Tcr	≥ +8.5						≥ +4.5					

[a] - Based on low temperature PG requirement of area (NCHRP 9-59)
[b] - Only determine ΔTf when -6 ≤ ΔTc ≤ -2.0; [c] - Only determine ΔTf when -7.0 ≤ ΔTc ≤ -3.0

→ Glover Rowe Parameter Replaces G*sinδ

Specification Limit – 20 hr PAV

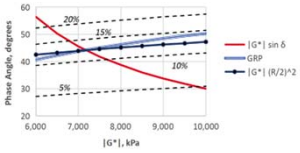
Specification Limit – 40 hr PAV

→ Multiple Relaxation Parameters

Adapted from Tom Bennert for WHRP (WisDOT) Research Project, "Benchmarking ΔTc for Wisconsin Materials

NCHRP 9-59 – Glover Rowe Parameter (GRP)

- Replace G*sind with GRP at 10 rad/s
- GRP = G*cos²δ/sinδ
- Increase limits to account for variability (40%).
  - 6000 kPa limit d2s GRP = 2400 kPa
  - 6000 kPa limt d2s G*sind = 1620 kPa
- Need to understand variability and impacts on compliance



- Dashed lines show equal fatigue strain capacity (FSC)
- Primary takeaway is that current parameter does not control FSC of binders as well as GRP.

NCHRP 9-59 – New IT Test Temperature

- Current system: IT PG = ((HT PG + LT PG)/2) +4
  - M320: Test temperature will increase for modified binders (i.e. PG 58-28 = 19C, PG 64-28 = 22C)
  - M332: Test temperature will stay the same with modification.
- New system: Based on LT PG only
  - Increase for soft grades, decrease harder grades

Low PG Grade °C	Proposed Binder Fatigue Test Temp. °C
-46	15
-40	17
-34	19
-28	22
-22	25
-16	27
-10	29

NCHRP 9-59 R-Value

- Determined from BBR cert. data.
- Additional parameter on aged material.
  - 20 hr PAV, require R from 1.50 to 2.00
  - 40 hr PAV, require R from 2.00 to 3.20
- Highly correlated to ΔTc
  - Research report states they can be used interchangeably.
- Parameter to address non-load associated cracking not in current specifications.

$$R = log(2)\frac{log(S/3{,}000)}{log(1-m)}$$

NCHRP 9-59 Results

- Good performance
  - 6 of 7 pass thresholds.
- Moderate performance
  - 3 of 4 pass thresholds.
- Poor performance
  - 4 of 5 identified as failing.
  - Failing binder includes VTAE and was expected to fail but did well.

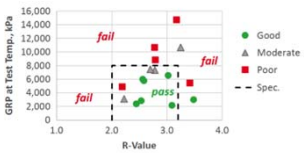
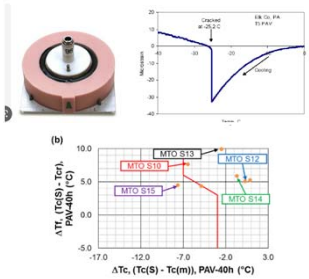


Figure 64. Proposed binder fatigue specification as applied to NCHRP 09-59 binders after RTFOT/40-hour PAV aging. Coded for estimated fatigue performance.

NCHRP 9-60

- Tiered Specification based on ΔTc and ΔTf
  - ΔTc ≥ -2°C, **Pass**
  - ΔTc ≤ -2°C and ≥ -6°C, Evaluate ΔTf
  - ΔTc <-6°C, **Fail**
- Estimate that 40-50% of binders supplied would require ΔTf.
- Impact on PMAC. Issues with ΔTc for PMA was a factor for ABCD/ΔTf development.



NCHRP 9-61

- No changes to current RTFO or 20 hour PAV aging.
- Evaluated extended PAV using 40 hr PAV (50 g) and 20 hr PAV (12.5g).
  - Challenges with 12.5 g procedure that can cause increased variability.
  - Concluded that changing PG spec to 40 hr aging requires significant validation efforts.
- Agencies are interested in extended aging. Treat as a PG plus test.
  - Specifications in place for ΔTc
  - Limits for R value and GRP proposed by 9-59
  - Limits for ΔTc and ΔTf planned for 9-60

Relating Research Projects to Durability Improvement Goals

Approach	NCHRP 9-59	NCHRP 9-60	NCHRP 9-61
Improve Binder Fatigue Parameter	Replace G*sinδ with GRP	ΔT_f for certain binders	N/A
Incorporate Relaxation	R Value	ΔT_c	N/A
Extended Aging	Specification Limits for 20 and 40 hr PAV	Specification Limits for 20 and 40 hr PAV	Test Procedures for Extended Aging (40 hr PAV)

- NCHRP 9-60 requires new equipment (ABCD Device)
- NCHRP 9-59 does not require new equipment, only different analysis methods.
- NCHRP 9-61 does not require new equipment.

Options for Relaxation Properties

	Delta Tc (ΔTc)	NCHRP 09-59 R-value	Phase Angle (δ) at Specified Value of G*[1]
Testing need?	BBR at 2 or more temperatures to bracket S=300 MPa and m=0.300 Calculate Tc,S and Tc,m	BBR at 1 temperature (Low Temperature PG) Use S(60) and m(60) to calculate R	DSR at 2 or more intermediate temperatures to bracket specified value of G* Determine Tc,G* Calculate phase angle (δ) at Tc,G*

- ΔTc (9-60) and R-value (9-59) are based on NCHRP Project recommendations.
- Phase angle at constant G* is an option being evaluated by industry.

Challenges

1. NCHRP Program committed $2.9 million in asphalt binder research since 2016. There will be pressure to implement.
2. Many state agencies have already implemented specifications to address durability including new tests/parameters and aging conditions.
3. Specification Proliferation and Test Selection
   - 9-59 and 9-60 propose two different systems to address similar issues.
   - Tests and specification criteria differs by state and is not in-line with research.
   - Are these the correct tests?
4. Variability of most tests is unknown.
5. 9-60 won't be complete for 1-2 years.

Setting Threshold Values – Current Status

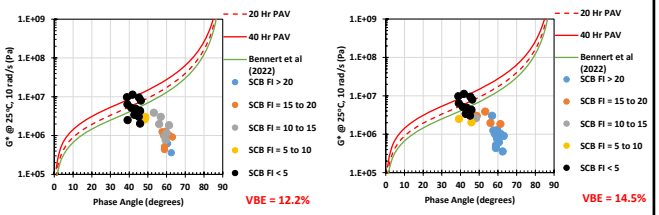
Excerpt from 9-59 Report

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.

Considerations in Setting Thresholds

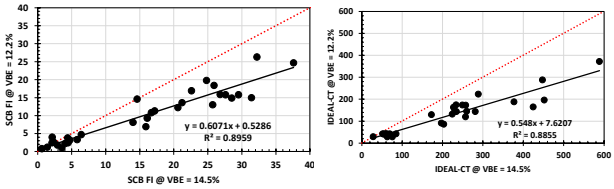
- PG ≠ Performance, PG = Purchase
- Durability is a mix performance issue. Function of:
  - Added binder properties.
  - Mix composition (including RAP and RAS), effective AC, etc.
  - Production and construction.
- Thresholds should not unreasonably restrict supply. Relative contribution of binder properties remains unknown.
- Promote BMD as a way to address varying binder properties.

Research by Tom Bennert for WHRP



- Virgin mixes all laboratory aged. AC was recovered and tested.
- Demonstrates interrelationships between durability and mix composition. Higher film thickness = less aging.
- Improvement across all 5 FI categories

Effect of VBE on BMD Cracking Tests (Bennert, AMAP 2023)



- 40% Decrease in cracking test for a 2.3% decrease in VBE

Opportunities

- Collaborate with AASHTO to evaluate M320 and M332.
  - The flood of new parameters has created confusion for everyone.
  - Industry can recommend tests and provide input on adjusting limits.
- Reduce specification proliferation
  - Messaging: Spec changes are aimed at improving durability.
  - New parameters are related to interim steps taken by DOTs (i.e. ΔTc vs. R).
- Industry involvement on the "Ground Floor"
  - The specification will evolve with time. This gives a mechanism to provide input. (This type of relationship has been lacking since ETGs were cancelled).
  - Significant risk in waiting

TAC NCHRP Project Task Force

- Member Companies
  - Imperial Oil, Marathon Petroleum, Valero, Kraton, Associated Asphalt, Mathy Construction, Vitol, Ergon,
- Asphalt Institute Support
  - Central Office: Mike Anderson, Mark Buncher, and Wes Cooper
  - Regional Engineers: Greg Harder and Amma Wakefield

Goals of Task Force

1. Understand Research Recommendations and Identify Potential Gaps.
2. Assess Proposed Threshold Values and Impact on Current Supply
3. Quantify Variability of New Parameters
4. Recommend Changes to Current AASHTO Specifications
5. Develop Outreach Plan
   - Provide consistent guidance to AI Regional Engineers
   - Interface with stakeholders (i.e. AASHTO and state agencies)

Task Force Activities

1. Develop Analysis Tool for Members to Assess Current Products with New Specifications
2. Round Robin Testing Program to Assess Variability

Task Force Activities
Analysis Tool - Inputs

Data Entry - 8mm DSR at 10 rad/s							
20 hour PAV				40 hour PAV			
Temperature, °C	G* kPa	Phase Angle, deg	Log G*	Temperature, °C	G* kPa	Phase Angle, deg	Log G*

Data Entry - T313 - BBR at 60 Sec							
20 hr PAV				40 hr PAV			
Temperature, °C	S(60), MPa	m(60)	Log S(60)	Temperature, °C	S(60), MPa	m(60)	Log S(60)
16				16			
10				10			
4				4			
-2				-2			

Task Force Activities
Analysis Tool - Outputs

Summary Table				
Parameter	Temperature, °C	Limit	Result	PASS/FAIL
Tests on 20 PAV Aged Residue				
δ at G* =8967 kPa, deg (PAV 20)	N/A	42, min	44.5	PASS
δ at G* =10,000 kPa, deg (PAV 20)	N/A	42, min	43.8	PASS
Glover Rowe Parameter, kPa (PAV 20)	19	5000, max	3768	PASS
Glover Rowe Parameter, kPa (Measured) (PAV 20)	22	5000, max	2336	PASS
Glover Rowe Parameter, kPa (Est) (PAV 20)	22	5000, max	2232	PASS
R-Value (PAV 20)	-18	1.5 - 2.0	1.90	PASS
ΔTc, °C (PAV 20)	N/A	≤-2.0 (ABCD Required), < -6.0 (Fail)	0.6	PASS
ΔTf, °C (PAV 20)	N/A	8.5, min	N/A	N/A

Same table is available for 40 hour PAV Results

Task Force Activities
Round Robin Testing Program

- Unmodified Asphalts (6)
  - PG 64-22: Four asphalts from three suppliers. ΔT_c ranging from >0 to -7°C. From domestic and European sources.
  - PG 52-28
  - PG 70-22
- Modified Asphalts (2)
  - PG 58V-34: Commercial supply, popular grade in NC US.
  - PG 76E-28: Highly polymer modified.

Task Force Activities
Round Robin Testing Program - Survey

1. What is the standard process used by your lab for 40 hour PAV?
   - 20 hour + 20 hour
   - 40 hour continuous
   - Other
2. Does your lab have the ability to run continuous 40 hour PAV?
3. Is it standard practice in your lab to vacuum de-gas PAV residues prior to testing?
4. Does your lab have the ability to vacuum de-gas?

Next Steps

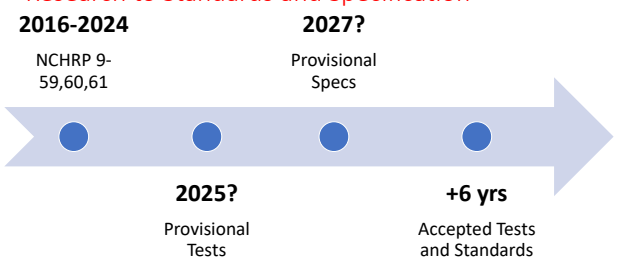
- Begin internal testing to evaluate new parameters and thresholds.
- Complete round robin testing program.
- Establish communication with AASHTO COMP Section 2B
  - Inform them on plans.
  - Solicit feedback on AASHTO needs from industry.
  - Recommend a validation period is needed.
  - Provide data driven proposal for changes.
- Outreach to other AASHTO COMP Sections
  - Effect of binder properties on cracking performance relative to other factors needs to be understood.
- Work at a regional level to slow down spec. proliferation.

Main Takeaways

- Proposed changes are not trivial and will take time to evaluate.
- Disbanding the ETGs has created an education vacuum.
  - Regions/states are acting alone because consistent guidance is lacking.
  - Same issues observed with BMD.
  - How can industry and the AI TAC help?
- Take advantage of opportunity to collaborate.
- Be willing to adapt as new information is available.

New Binder Parameters

Research to Standards and Specification



Thank You!

Andrew Hanz
MTE Services, a division of Mathy Construction
608-347-0871
Andrew.hanz@mteservices.com