Testing and Specification for Performance-Graded Emulsified Asphalt

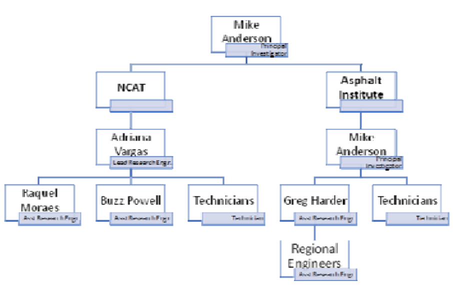
Mike Anderson
Asphalt Institute

SEAUPG Annual Meeting
Baton Rouge, LA November 20, 2019

Emulsified Asphalt Performance Grading (EPG)

- NCHRP 09-63
  - "A Calibrated and Validated National Performance-Related Specification for Emulsified Asphalt Binder"
  - Project started May 1, 2019
  - Expected completion by May 1, 2023
  - Phase 1
    - Approximately 6 months
  - Phase 2
    - Subject to approval by Project Panel
    - Remaining 42 months

NCHRP 09-63 Research Team



Project Objectives

- Develop a national performance-related material specification for emulsified asphalt binder for use with chip seals and microsurfacing/slurry seals that:
  - a) is similar in concept and format to AASHTO Standard Specifications M320 and M332;
  - b) is calibrated and validated with performance data from field test sections;
  - c) uses readily available testing equipment (i.e., Superpave test equipment); and
  - d) reflects varying climatic and traffic conditions.

Project Objectives

- Develop a national performance-related material specification for emulsified asphalt binder for use with chip seals and microsurfacing/slurry seals that:
  - a) is similar in concept and format to AASHTO Standard Specifications M320 and M332;
  - b) is calibrated and validated with performance data from field test sections;
  - c) uses readily available testing equipment (i.e., Superpave test equipment); and
  - d) reflects varying climatic and traffic conditions.

ETF Draft Specification will be used as the starting point

EPG Draft Specification (from ETF)

Table 1 - Performance Graded Emulsified Asphalt Specification

Performance Grade	EPG 49				EPG 55					EPG 61				
	-25	-31	-37	-43	-19	-25	-31	-37	-43	-19	-25	-31	-37	-43
Average 7-day max pavement surface design temperature[a], °C	< 49				< 55					< 61				
Min pavement surface design temperature[a], °C	> -25	> -31	> -37	> -43	> -19	> -25	> -31	> -37	> -43	> -19	> -25	> -31	> -37	> -43
Tests on Residue Recovered Using AASHTO R 78, Procedure B														
High Temperature Performance Parameter														
Dynamic shear, T 315: $G^*/\sin\delta$, min 0.65 kPa, test temp @ 10 rad/s, °C	49				55					61				
Low Temperature Performance Parameter														
Critical phase angle, δ_c, degree	45	42	39	36	48	45	42	39	36	48	45	42	39	36
DSR Temperature Frequency Sweep, NCHRP Report 837	5°C, 15°C, and 25°C													
Low[b] traffic max G^* at δ_c, MPa	30	30	30	30	30	30	30	30	30	30	30	30	30	30
High[c] traffic max G^* at δ_c, MPa	20	20	20	20	15	20	20	20	20	15	20	20	20	20
OPTIONAL: polymer identification parameter														
Max. phase angle[d] (δ) @ temp. where $G^*/\sin\delta$ = 0.65 kPa	–	–	84[e]	84[e]	–	–	84[e]	84[e]	84[e]	–	84[e]	84[e]	84[e]	84[e]

a. Temperatures are at the surface of the pavement structure. These may be determined from experience or may be estimated using equations developed by SHRP or LTPP, but modified to represent surface temperatures. Surface-grade high temperatures are generally 3°C to 4°C greater than those determined for Superpave PG binders.
b. Low traffic is defined as any roadway with an AADT between 0 and 1000 vehicles.
c. High traffic is defined as any roadway with an AADT between 1001 and 20,000 vehicles.
d. Phase angle is determined at the temperature where $G^*/\sin\delta$ = 0.65 kPa. For routine testing and quality assurance, the phase angle can be interpolated from testing at two temperatures, one above and one below where $G^*/\sin\delta$ = 0.65 kPa
e. If required by the buyer, change to 80° for SBS/SB modified emulsions.

Developing the Draft ETF Specification

- ETF Testing Program in 2017-18 was instrumental in developing the draft specification
  - The principal goals of the 2017 ETF Testing Program were to:
    - Determine appropriate procedures to be used for high and low temperature rheological properties
    - Determine the need for long-term aging
    - Evaluate procedures intended to ensure the quality of polymer modification without excluding good performers

Residue Recovery Procedure

- AASHTO R78, Procedure B
  - "Recovering Residue from Emulsified Asphalt Using Low-Temperature Evaporative Techniques"
    - Thin film, silicone mat
    - Forced draft oven at 60°C for 6 hours
  - High and Intermediate temperature testing for performance grading

2017 ETF Testing Program

- High Temperature Testing on Recovered Residue
  - EPG High Temperature Parameter (NCHRP 09-50, NC State)
    - MSCR Jnr-3.2 values higher than typically seen for paving binders
      - Likely caused by two factors
        - Emulsion residue is most like original instead of RTFO-aged binder (factor of ~2 for Jnr)
        - Grade temperature 3°C higher for surface treatments than paving asphalt mixtures (factor of ~1.25 for Jnr)
      - As a result, unmodified emulsions generally fail
    - May need to revisit criterion for Low traffic applications and/or change test parameters of MSCR procedure
      - Use temperature that is uniformly lower than surface temperature by some amount (not ideal)
      - Set criterion for Jnr at lower stress level (e.g., 0.1 kPa shear stress)

2017 ETF Testing Program

- High Temperature Testing on Recovered Residue
  - SPG High Temperature Parameter (Texas A&M)
    - G*/sin δ criterion generally was met, with some failures
    - Variability between labs appeared higher than expected in some instances
      - Could be a function of residue recovery procedure?

Draft ETF Specification

- High Temperature Parameter in Draft Specification
  - Selected the SPG high temperature parameter (Texas A&M)
    - G*/sin δ criterion appeared to provide adequate discrimination
    - Variability known to be lower than variability from MSCR test, irrespective of any variability due to the residue recovery procedure
  - Continue to evaluate MSCR Jnr as possible high temperature parameter
    - Some agencies have already transitioned to AASHTO M332 for paving grade asphalt binders; more expected in the future

2017 ETF Testing Program

- Intermediate/Low Temperature Testing on Recovered Residue
  - EPG Low Temperature Parameter (NCHRP 09-50, NC State)
    - Tested on as-recovered residue
    - Criteria based on maximum allowable G* at critical phase angle (δ_c), based on low temperature grade
      - Temperature-frequency sweep test
        - DSR using 8-mm parallel-plate geometry, following draft research procedure
        - Two temperatures (5, 15°C)
        - 0.1-100 rad/s, logarithmically spaced with 10 loading frequencies per decade
      - Mastercurve generated at T_{ref}=15°C to determine G* at δ_c

2017 ETF Testing Program

- Intermediate/Low Temperature Testing on Recovered Residue
  - SPG Low Temperature Parameter (Texas A&M)
    - Tested on recovered residue subjected to further PAV aging
    - Criteria based on maximum allowable BBR Stiffness at 8 seconds loading at low temperature grade

Draft ETF Specification

- Low Temperature Parameter in Draft Specification
  - Selected the EPG low temperature parameter (NC State)
    - BBR testing resulted in similar low temperature grade for all recovered residue
    - More residue required for BBR than DSR
    - Added step of PAV aging
  - G* at δ_c
    - DSR test
      - Less residue needed for 8-mm parallel plate geometry than BBR
    - Showed some discrimination between different residues
    - Rational response with temperature changes
    - Not without some challenges

Draft ETF Specification

- Polymer Presence in Draft Specification
  - Uses maximum phase angle requirement at $T_{c,high}$
    - $T_{c,high}$ = temperature where G*/sin δ = 0.65 kPa
    - From Texas A&M research
  - Concerns comparing values for SBR-modified residues compared to SBS-modified residues
  - Not a true performance-based parameter
    - Use as an EPG-Plus test?
      - Similar to manner in which user agencies ensure polymer modification for paving asphalt binders

Residue Recovery Procedure

- What was learned from the 2017 ETF Testing Program?
  - Time from residue recovery to testing appears to matter in measured test values
- How was that lesson applied to the 2018 ETF Testing Program?
  - The following guidance was provided to labs:
    - "Before recovering the asphalt emulsion, please ensure that the test procedures will be conducted on the recovered residue within 48 hours after recovery."

Residue Recovery Procedures (2018 Program)

- AASHTO R78, Procedure B
  - "Recovering Residue from Emulsified Asphalt Using Low-Temperature Evaporative Techniques"
- AASHTO T59, Section 7
  - "Emulsified Asphalt Residue by Evaporation"
    - Forced draft oven at 163°C for 3 hours
  - Modified asphalt emulsions only
    - Intended to put SBR and SBS modified residues on more even field for comparison
  - High temperature testing for polymer identification
  - Added to 2018 ETF Testing Program based on analysis from 2017 data

2018 ETF Testing Program

- High Temperature Testing on Recovered Residue
  - Determination of G*/sin δ
    - Testing Details
      - Perform in accordance with AASHTO T315
      - 25-mm parallel plate geometry, 1-mm gap, 12% shear strain
      - Temperature sweep starting at 55°C and proceeding in 6°C increments until failure (the point where G*/sin δ is less than 0.65 kPa)
    - Report
      - G*/sin δ at each temperature
      - δ at each temperature
      - $T_{c,high}$ – the continuous high temperature grade where G*/sin δ = 0.65 kPa
      - δ at $T_{c,high}$ – the value of phase angle at the continuous high temperature grade

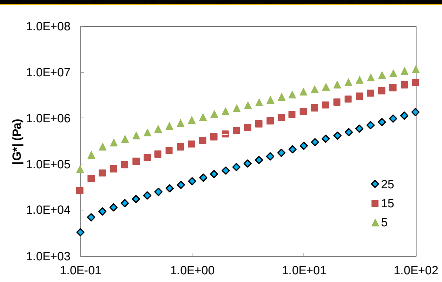
2018 ETF Testing Program

- High Temperature Testing on Recovered Residue
  - Determination of MSCR Parameters
    - Testing Details
      - Perform in accordance with AASHTO T350
      - 25-mm parallel plate geometry, 1-mm gap
      - Test temperature at 3°C higher than LTPPBind Grade Temperature (as indicated with sample) and at 3°C lower than LTPPBind Grade Temperature
        - Corresponds to surface PG and 6°C lower than surface PG, respectively
      - Use a new test specimen for each temperature
    - Report
      - $J_{nr0.1}$ and $J_{nr3.2}$ at each temperature
      - $R_{0.1}$ and $R_{3.2}$ at each temperature

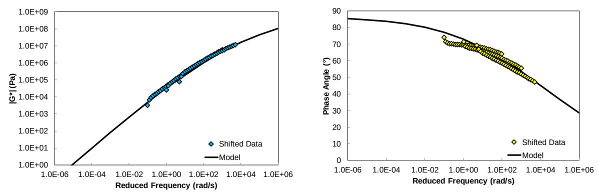
2018 ETF Testing Program

- Intermediate-Low Temperature Testing on Recovered Residue
  - Determination of G* at critical phase angle (δ_c), reported as G_c
    - Testing Details
      - Perform in accordance with Research Draft Standard
      - 8-mm parallel plate geometry, 2-mm gap, 1% shear strain
      - Frequency sweep at each temperature starting at 0.1 rad/s and proceeding to 10 rad/s using 10 loading frequencies per decade.
      - Three temperatures starting at 25°C, then proceeding to 15°C, and finally 5°C
    - Report
      - G* and δ at each temperature and frequency
      - G_c at critical phase angle (based on surface low temperature grade)

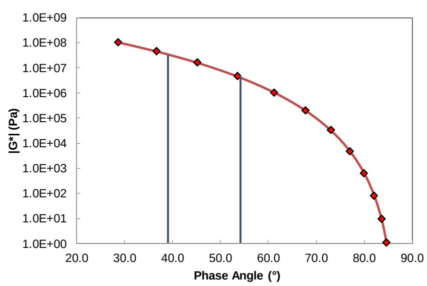
Isotherms



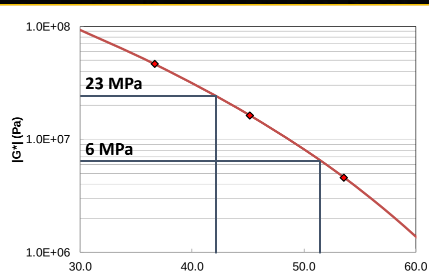
Shifted Data



Shifted Data – Black Space



Shifted Data – Black Space



2018 ETF Testing Program

- Some Key Takeaways from the Analysis
  - Consistency in residue recovery is important to minimize variability
    - AASHTO R78, Procedure B has higher variability – particularly for high temperature results
    - AASHTO T59, Section 7 mitigates some of the variability, but changes the values

2018 ETF Testing Program

- Some Key Takeaways from the Analysis
  - Phase angle limits for polymer identification generally separate modified from unmodified emulsion residues using AASHTO R78 Procedure B recovery
    - 84-degree maximum generally segregates unmodified from modified residue
  - AASHTO T59, Section 7 recovery appears to make all modified residues more easily pass the criterion
    - Generally greater effect on latex-modified (SBR) residue than polymer-modified (SBS) residue

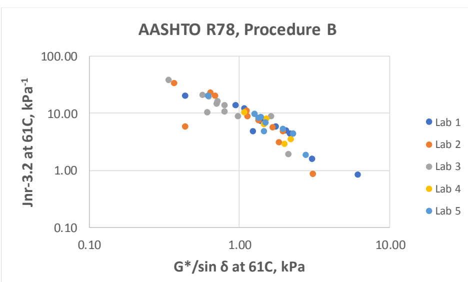
2018 ETF Testing Program

- Some Key Takeaways from the Analysis
  - Intermediate temperature properties appear to be strongly impacted by low temperature grade
    - The lower the low temperature grade, the higher the G* at δc…regardless of whether the residue is unmodified or modified
    - Function of the base asphalt binder?
      - May see changes once formulations change to meet new specification

2018 ETF Testing Program

- Some Key Takeaways from the Analysis
  - MSCR limits suggested by NCHRP 09-50 may need to be re-evaluated
    - A G*/sin δ value of 0.65 kPa is comparable to a Jnr-3.2 value of approximately 17.6 kPa^{-1}
      - Twice as high as the limit for low traffic from NCHRP 09-50 research
      - How much will change when formulations change to adapt to new specification?

2018 ETF Testing Program



2018 ETF Testing Program

- Some Key Takeaways from the Analysis
  - MSCR
    - $J_{nr,3.2}$ variability still high
      - Not helped by variability in recovery procedure
    - Testing at temperature of EPG-6 appears more appropriate for discrimination of results
    - $R_{0.1}$ at temperature of EPG-6 appears appropriate for discrimination of results
      - Average of CRS-2 residue = 4%
      - Average of CRS-2L residue = 42%
      - Average of CRS-2P residue = 57%

NCHRP 09-63 Activities

- Phase 2
  - Conduct Experimental Plan
  - Propose Final Specification
  - Communicate Findings through Presentations
  - Provide Final Report

NCHRP 09-63 Field Experiments

- NCAT/MnROAD Partnership
  - Low Traffic
    - CSAH-8 (near Pease, Minnesota) – reported as 700 vehicles per day
    - Lee Road 159 (Auburn, Alabama) – reported as 1,200 vehicles per day with 60% trucks
  - High Traffic
    - US-169 (near Pease, Minnesota) – reported as 16,000 vehicles per day
    - US-280 (near Opelika, Alabama) – reported as 17,000 vehicles per day with 16% trucks.

NCHRP 09-63 Field Experiments

- New/Existing Chip Seal and Microsurfacing/Slurry Seal Projects
  - Identify a minimum of 16 projects in the four environmental regions (Wet-Freeze, Wet-No Freeze, Dry-Freeze, and Dry-No Freeze)
    - Laboratory testing will be performed on the asphalt emulsion using the draft specification developed in Phase I.
    - Follow-up observations in subsequent years

NCHRP 09-63 Field Projects

- Lab Testing on Emulsion Residue
  - low temperature evaporation to produce emulsion residue;
  - high temperature testing at appropriate surface temperatures to determine G*/sin δ (AASHTO T315);
  - high temperature testing at appropriate surface temperatures and stress to determine Jnr (AASHTO T350);
  - evaluation of the phase angle at the temperature where G*/sin δ = 0.65 kPa;
  - evaluation of MSCR Recovery at appropriate temperature and stress (for polymer modified emulsion residue); and
  - intermediate temperature testing to assess the low temperature properties of the emulsion residue using temperature-frequency sweep testing on the DSR to determine G* at δ_c

NCHRP 09-63 Field Projects

- Follow-up evaluation of projects
  - condition of the surface treatment
  - micro-sampling, extraction/recovery of the emulsion residue, and testing
    - conditions in service can be better correlated with the properties of the in-situ emulsion residue.

95th AAPT Annual Meeting and Technical Sessions

The 2020 Annual Meeting will be held March 22-25, 2020
Westin San Diego Gaslamp Quarter, San Diego, California USA

Our 2020 venue
Westin San Diego Gaslamp Quarter

2020 Annual Meeting

The Annual Business Meeting and Technical Sessions of the Association of Asphalt Paving Technologists (AAPT) will be March 22-25, 2020 in San Diego, California at Westin San Diego Gaslamp Quarter. The annual meeting includes asphalt-related technical sessions comprised of peer-reviewed papers, and invited presentations on specific topics in the AAPT-ISAP International Forum, and Symposium as well as a Student Poster Session.

Visit http://asphalttechnology.org/annual-meeting.html for more details as they become available.

Important dates

December 2019 – Annual Meeting registration opens
March 22-25, 2020 - Annual Business Meeting and Technical Sessions

AAPT
Association of Asphalt Paving Technologists

AAPT Office:
6776 Lake Drive, Suite 215
Lino Lakes, MN 55014
Phone: 651-293-9188
Email: aapt@asphalttechnology.org

For the latest information please check our web site at: http://www.asphalttechnology.org

Become an AAPT Member!

http://asphalttechnology.org/membership.html

- Have access to a wealth of information and emerging technologies including free webinars
- Be an integral part of a technical community comprised of individuals from all parts of the asphalt industry (material suppliers, researchers, agency owners, consultants, and equipment manufacturers)
- Enjoy the camaraderie of colleagues in the field during annual meetings at attractive venues
- Be a part of lively debates on important technical issues
- Belong to a North American-based organization with significant international membership and focus
- Be a member of an association that operates without organizational biases; policies set by and for individual members by an elected Board
- Support the next generation of asphalt technologists through a robust student scholarship program

NCHRP 09-63

- Questions or Comments?

Mike Anderson	Adriana Vargas
Principal Investigator	Lead Research Engineer
Asphalt Institute	National Center for Asphalt Technology
manderson@asphaltinstitute.org	vargaad@auburn.edu
859-288-4984	334-844-7303

Thanks!

Global, International, Regular, Associate and Canadian members

Affiliate and Commercial members