Testing and Specification for Performance-Graded Emulsified Asphalt

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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.

ETF Draft Specification will be used as the starting point
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 ~6 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)
    - $G*/\sin \delta$ 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?

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**Draft ETF Specification**

- High Temperature Parameter in Draft Specification
  - Selected the SPG high temperature parameter (Texas A&M)
    - $G*/\sin \delta$ 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 Jrn as possible high temperature parameter
      - Some agencies have already transitioned to AASHTO M332 for paving grade asphalt binders; more expected in the future

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**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 ($\delta_c$), 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 $\delta_c$
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 $\delta$
      • 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 $T_{c,\text{high}}$
    • $T_{c,\text{high}}$ = temperature where $G^*/\sin \delta = 0.65$ 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 $G^*/\sin \delta$
    • 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 $G^*/\sin \delta$ is less than 0.65 kPa)
    • Report
      • $G^*/\sin \delta$ at each temperature
      • $\delta$ at each temperature
      • $T_{99.9\%}$ – the continuous high temperature grade where $G^*/\sin \delta = 0.65$ kPa
      • $\delta$ at $T_{99.9\%}$ – 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
      • Test temperature at 3°C higher than LTPPBind Grade Temperature (as indicated with sample) and at 3°C lower than LTPPBind Grade Temperature
      • Use a new test specimen for each temperature
    • Report
      • Jnr0.1 and Jnr3.2 at each temperature
      • R0.1 and R3.2 at each temperature

2018 ETF Testing Program

• Intermediate-Low Temperature Testing on Recovered Residue
  • Determination of $G^*$ at critical phase angle ($\delta_c$), 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 $\delta$ at each temperature and frequency
      • $G_c$ at critical phase angle [based on surface low temperature grade]

Isotherms
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

• 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

• 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
• Some Key Takeaways from the Analysis
  • MSCR limits suggested by NCHRP 09-50 may need to be re-evaluated
    • A $G^*/\sin \delta$ 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

AASHTO R78, Procedure B

$G^*/\sin \delta$ at 61°C, kPa

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<tr>
<th>Lab 1</th>
<th>Lab 2</th>
<th>Lab 3</th>
<th>Lab 4</th>
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• Some Key Takeaways from the Analysis
  • MSCR
    • $J_{UL}$ variability still high
    • Not helped by variability in recovery procedure
    • Testing at temperature of EPG-6 appears more appropriate for discrimination of results
    • $R_{UL}$ at temperature of EPG-6 appears appropriate for discrimination of results
    • 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.

#### 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 $G^*/\sin \delta$ (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 $G^*/\sin \delta = 0.65$ 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 $\delta_c$.

- 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

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Westin San Diego Gaslamp Quarter, San Diego, California USA

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• Support the next generation of asphalt technologists through a robust student scholarship program

NCHRP 09-63

• Questions or Comments?

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Thanks!