NCHRP 9-43
Mix Design Practices for Warm Mix Asphalt

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Outline

• Objective and Approach
• Major Conclusions and Products
• Proposed Appendix to AASHTO R 35
• Recommended Additional Research
Objective

• To adapt laboratory mixture design and analysis procedures to WMA
  – Compatible with HMA procedures
  – Address wide range of warm mix processes
• Current
• Future
Approach

• Preliminary Procedure
  ✓ Focus Experimental Work

• Phase I Experiments
  ✓ Reheating
  ✓ Binder Grade
  ✓ RAP Mixing
  ✓ Short-Term Conditioning
  ✓ Workability
Approach (Continued)

• Revised Preliminary Procedure
• Phase II Experiments
  ✓ Expanded RAP Mixing
  ✓ Laboratory Mix Design
  ✓ Field Validation
  ✓ Limited Fatigue Study
• Final Draft Procedures
• Documentation
Approach (Continued)

- Revised Preliminary Procedure
- Phase II Experiments
  - Expanded RAP Mixing
  - Laboratory Mix Design
  - Field Validation
  - Limited Fatigue Study
- Final Draft Procedures
- Documentation
Expanded RAP Mixing Experiment

- Effect of Time at WMA Compaction Temperature on Degree of Mixing of RAP and New Binders

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- Paired t-test to Compare Properties
  - Volumetric
  - Performance
### Field Validation

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Major Conclusions

• WMA can be designed with only minor changes to AASHTO R35
  – Specimen fabrication procedures
  – Coating and compactability in lieu of viscosity based mixing and compaction temperatures

• WMA design is challenging for plant foaming process
  – Laboratory foaming devices need improvement
Lab Simulation of Plant Foaming

Laboratory Foaming

Before Mixing

After Mixing
Major Conclusions

• For mixtures using the same aggregates and binders and having binder absorption less than 1 percent
  – Volumetric properties of WMA and HMA are very similar
  – Compactability, moisture sensitivity, and rutting resistance may be different when designed as WMA compared to HMA
• Supports need for design procedure
Volumetric Properties

Design Binder

Absorption
Primary Products

- Draft Appendix to AASHTO R35, *Special Mixture Design Considerations and Methods for Warm Mix Asphalt (WMA)*
- Commentary to Draft Appendix
- Training Materials for Draft Appendix
Draft Appendix to R35

- Equipment for Designing WMA
- WMA Process Selection
- Binder Grade Selection
- RAP in WMA
- Process Specific Specimen Fabrication Procedures
- Evaluations
  - Coating
  - Compactability
  - Moisture Sensitivity
  - Rutting Resistance
- Adjusting the Mixture to Meet Specification Requirements.
Additional Equipment

• Mechanical mixer
  – Type of mixer matters (Planetary vs Bucket)
  – Recommended mixing times and coating criteria based on Planetary mixer

• Low shear mechanical stirrer
  – Blending additives with binder

• Laboratory Foaming Device
  – Designs for plant foaming processes. Currently available devices require improvement
Process Selection

- Numerous Processes
- Consult with Agency and Process Suppliers
- Consider
  - Available performance data
  - Cost of the warm mix additives
  - Planned production and compaction temperatures
  - Planned production rates
  - Plant capabilities
  - Modifications
Binder Grade Selection

• Same as HMA
  – Field validation did not support high temperature grade bumping

• Note that grade bumping may be required to meet rutting resistance criteria
Recovered Binder Grade

High Temperature

Low Temperature

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RAP

• High temperature grade of RAP should be lower than compaction temperature
  – RAP mixing study
  – MD and VA most RAP grades as PG 88 or 94
  – Compaction temperature should be greater than 94 C (200 F)
Specimen Fabrication Procedures

• Major portion of Appendix
• Generic
  – Additive added to binder
  – Additive added to mixture
  – Wet aggregate mixtures
  – Foamed asphalt mixtures
Evaluations

• Coating
  – One sample
  – Mechanical planetary mixer
    • Mixing times probably different for bucket mixers
  – AASHTO T195, 95 percent of coarse aggregate particles fully coated
Evaluations

• Compactability
  – Four gyratory samples
  – Maximum specific gravity sample
  – STOA 2 hours at compaction temperature
  – Gyrations to 92 % of Gmm at compaction temperature and 30 °C below compaction temperature
  – Ratio of gyrations at 30 °C below compaction temperature to gyrations at compaction temperature should be less than 1.25
Compactability

Temperature

Process
Evaluations

- Moisture Sensitivity
  - AASHTO T283
  - STOA 2 hours at compaction temperature
  - AASHTO M323 requirement of tensile strength ratio > 0.80
Mix Design Study TSR

TSR

Dry Strength

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# Field Section TSR

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Evaluations

• Rutting Resistance
  – Flow number test, AASHTO TP79
    • NCHRP 9-33 test conditions
      – Unconfined
      – 600 kPa repeated deviator stress
      – 7 percent air voids
      – 50 percent reliability temperature from LTPPBind 3.1
    – STOA 2 hours at compaction temperature
  – 4 specimens
  – Modified NCHRP 9-33 Criteria
    • Reduced aging of WMA
Mix Design Study Rut Resistance

Temperature

Process

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# Field Rut Resistance

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Adjusting the Mixture

- Coating
  - WMA process supplier
- Compactability
  - WMA process supplier
- Moisture Sensitivity
  - WMA process supplier
- Rutting Resistance
  - Effect of binder grade, filler content, VMA, and $N_{\text{design}}$, from NCHRP Report 567
Additional Research

- Many issues identified in Project 9-43 will be addressed by
  - NCHRP 9-47A, *Properties and Performance of Warm Mix Asphalt Technologies*
  - NCHRP 9-49, *Performance of WMA Technologies: Stage I--Moisture Susceptibility*

- Two mixture design issues may not be addressed
  - WMA mixing procedures for bucket mixers
  - STOA for Moisture Sensitivity and Rutting Resistance
Mixing Procedures for Bucket Mixers

- Mixing times included in Draft Appendix to R35 are based on a planetary mixer
- Bucket mixers are less efficient, but more readily available
- Establish mixing times for bucket mixers
  - Coating as a function of mixing time
    - HMA
    - WMA
Two Step Short-Term Conditioning

- AASHTO R30 for performance testing (4 hours at 135 °C) includes construction aging plus some time in service
  - Basis for many performance test criteria for HMA (flow number, Hamburg, etc)
- Two Step short-term conditioning is needed to use the same criteria for WMA
  - 2 hours at compaction temperature to simulate construction
  - Extended time at service temperature to simulate early aging
Questions/ Suggestions

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