Evaluation of Warm Mix Asphalt versus Conventional Hot Mix Asphalt for Field and Laboratory-Compacte...
Presentation Outline

• Background
• Study Objectives
• Project Description & Location
• Mixture Properties
• Scope of Work
• Specimen Preparation
• Data Analysis and Results
• Conclusions / Follow-up Work
Brief WMA Background

• Reduction on the viscosity of binder to allow for coating of the aggregate properly

• Chemical-based:
  • 30% reduction of the mixing temperature and no negative effects on rutting *(Hurley and Prowell, 2006)*
  • No reduction of dynamic modulus *(NCAT Report 06-02, 2006)*

• Foaming-based:
  • slightly lower moisture susceptibility compared to conventional HMA *(Wielinski et.al, 2009)*
Study Objectives

• Laboratory evaluation of three mixtures
  – Control HMA mix
  – Foaming-based WMA mix
  – Chemical-based WMA mix

• Testing:
  – Field cored specimens
  – Laboratory-compacted specimens

• Is it reasonable to reheat and test WMA loose mix in the lab?
Project Description & Location

- SR 85, Gila Bend, near Phoenix, Arizona
- Three different sections:
  - Control HMA section
  - Foaming-based WMA section
  - Chemical-based WMA section
Mixture Properties

- 3/4” ADOT 416 special mix
- PG 76-16 binder
- Asphalt content: 4.8%
- Target Air voids: 5.5 ± 0.2 %
- Lab mixing temperature = 330 °F
- Lab compaction temperature = 310 °F

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Scope of Work

• Laboratory specimens compacted at two temp:
  – 270 °F (132 °C)
  – 310 °F (154 °C)

• Laboratory testing included:
  – Dynamic modulus $|E^*|$ test
  – Indirect Diametral Tensile (IDT) Strength test
  – Tensile Strength Ratio (TSR) test for moisture damage evaluation

• Study with limited testing program
Testing Plan

- Foaming-based WMA
  - Field cores
  - Lab-compacted specimens
    - Compacted at 270 F
    - Compacted at 310 F

- Control HMA
  - Field cores
  - Lab-compacted specimens
    - Compacted at 270 F
    - Compacted at 310 F

- Chemical-based WMA
  - Field cores
  - Lab-compacted specimens
    - Compacted at 270 F
    - Compacted at 310 F
Specimen Preparation

- **Field-core specimens**
  - Stack for $E^*$ testing
  - Stacking (SPT by Witczak et al., 2000)
  - Un-stack for IDT & TSR testing

- **Lab-compacted specimens**
  - Reheated and compacted with SGC
  - Cored and sawed for $E^*$
  - Cut into 3 discs for IDT & TSR testing
Dynamic Modulus |E*| Test

- **AASHTO TP 62-07**
- **Test temperature:** 70 °F
- **Loading frequencies:** 25, 10, 5, 1, 0.5 and 0.1 Hz
- **Recoverable strain:** 50-150 με
- **Two spring-loaded LVDTs to measure the deformations**
E* Results – Field Cores

- Field Cores

Dynamic Modulus (MPa) vs. Frequency (Hz)

- CONTROL
- FOAMING-BASED
- CHEMICAL-BASED

1 MPa = 145.04 psi
E* Results – Control-Lab

Dynamic Modulus (MPa) vs Frequency (Hz)

- CONTROL @ 310 F
- CONTROL @ 270 F

1 MPa=145.04 psi
E* Results – Foaming-Lab

Dynamic Modulus (MPa) vs. Frequency (Hz)

- FOAMING @ 310 F
- FOAMING @ 270 F

1 MPa = 145.04 psi
E* Results – Lab Specimens

![Graph showing dynamic modulus (MPa) vs. frequency (Hz) for different specimens.]

- CONTROL @ 310 F
- CONTROL @ 270 F
- FOAMING @ 310 F
- FOAMING @ 270 F
- CHEMICAL @ 310 F
- CHEMICAL @ 270 F

1 MPa = 145.04 psi
### Statistical Analysis for E*-Lab Spec.

- Paired t-distribution for two variables
- Significance level $\alpha$ of 5%

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<th>Control Lab @ 270 °F</th>
<th>Control Lab @ 310 °F</th>
<th>Foaming Lab @ 270 °F</th>
<th>Foaming Lab @ 310 °F</th>
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Indirect Diametral Tensile (IDT) Strength Test

- AASHTO TP-94
- Test was performed @ 70 °F
- Specimen: 4” (100 mm) diameter and 2.0” (50 mm) thick
- Constant loading rate: 2 in/min (50 mm/min)
- IDT value is determined as the peak tensile strength value
IDT Results - Field Cores

![Graph showing peak tensile strength comparison between CONTROL, FOAMING-BASED, and CHEMICAL-BASED mix types. The graph indicates that CHEMICAL-BASED has the highest peak tensile strength at 1303 kPa, followed by FOAMING-BASED at 760 kPa, and CONTROL at 836 kPa.]

1 psi = 6.9 kPa
Tensile Strength Ratio (TSR), Moisture Sensitivity Test

- AASHTO T283
- Evaluate moisture damage
- TSR: Ratio of conditioned to unconditioned IDT
- Constant loading rate: 2 in/min (50 mm/min)

Freezing Cycle

Thaw Cycle
- Specimens compacted at 270°F
- ADOT Specs for acceptable TSR > 80%
Conclusions

A. Field Cores - E* and IDT results
   1. Both control and foaming-based WMA mixtures showed comparable results
   2. Chemical-based WMA mixture was relatively higher??

B. Laboratory compacted specimens
   1. Decreasing the compaction temperatures from 310 to 270 °F have less effect on the WMA mixes compared to control HMA
Conclusions

i. IDT Test:
   • Control: Strength reduced by 10% between temp
   • WMA: Strength reduced by 0.5 – 1.8%

ii. E* test:
   • Control: Strength reduced by 8%
   • WMA: strength reduced by 2 - 5%

2. Very good result despite doubts of the reheating

3. TSR results for all 3 mixtures were comparable, but lower than specifications, probably due to harsh freezing cycle.
Follow Up Work

• Hamburg Wheel Tracking test
  • Disagreed with TSR
• Field Evaluation Trip
  • Excellent performance
Recommendation

• Future projects: perhaps a portable gyratory compactor can be used at the asphalt plant in order to avoid reheating the WMA mixes
Acknowledgements

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  • Paul Burch, Pavement Design Section Engineer
  • Scott Weinland Pavement Materials Testing Section
• Mark Belshe, formerly with FNF Construction
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Thank you

Questions?