O'Hare Modernization Project: WMA/RAS Testing Update

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Outline

• Warm Mix Asphalt (WMA)
  – Lab Produced Mix
  – Field Produced Mix

• Recycled Asphalt Shingles
  – Background
  – Climatic Analysis at ORD
  – DIC DCT RAS Results

• Ongoing Work
OMP UIUC Laboratory Study

• Objectives
  – Address the feasibility of sustainable asphalt technologies by examining:
    • Rutting Resistance
    • Moisture Sensitivity
    • Low Temperature Performance
    • Long-term Durability
  – Materials:
    • Warm Mix Asphalt
    • Recycled Asphalt Shingles
Completed Research

• Evaluated Performance Characteristics of ORD WMA Mixtures
• Examined Effects of RAP and WMA Additive Interaction in Laboratory Produced Mixtures
  – Rutting, Thermal Cracking, and Moisture Resistance Performance Testing
• Determined the Effects of Production Temperature Reduction on Compactibility and Moisture Resistance
OMP WMA Field Study

• 2011
  – Wax Additive: Sonnewarm
  – Chemical Additive: Rediset LQ

• 2012
  – Foamed: 0.5% water
    • Binder Course
    • Surface Course

DCT Fracture Energy (J/m^2)
WMA TSR Results

(AASHTO T-283, Tensile Strength Ratio (TSR) Test for Moisture Sensitivity Assessment)

Sonnewarm N50 BAM
Sonnewarm N70 Surface
Rediset LQ 0.5%
Rediset LQ 0.75%
Foamed N70 Surface

0.8 Minimum
Foamed WMA Plant Retrofit – Gencor
Foamed WMA BAM Pilot Project
Foamed WMA Surface Mix Pilot Project
Roofing Asphalt Shingles

• Composition
  – Asphalt Binder
    • PG grade 136-4
  – Fiber Backing
    • Organic (cellulose or wood fiber)
    • Fiberglass
  – Aggregate
    • Powdered Limestone (70% passing #200 sieve)
    • Sand Granular
  – Roofing Felt
    • May contain asbestos
Recycled Asphalt Shingles

• What are they?
  – Post-Manufactured:
    • Waste from shingle plants
    • 1 million tons produced annually in US
  – Post-Consumer:
    • Tear-off roof shingle waste
    • 10 million tons generated annually

• Benefits of RAS in HMA
  – Reduced consumption of virgin materials
  – Reduced emissions during production
  – Reduced disposal in landfills
  – Improved public perception
  – Improved economic competitiveness
Recycled Tear-off Shingle Production

- Southwind RAS

Southwind RAS LLC

Less than 3/8"
Recycled Tear-Off Shingles Composition

<table>
<thead>
<tr>
<th></th>
<th>Southwind</th>
<th>Extraction</th>
<th>Ignition</th>
<th>Estimated Actual</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aggregate %</td>
<td>72.50%</td>
<td>63.11%</td>
<td>60.00%</td>
<td>60.00%</td>
</tr>
<tr>
<td>Asphalt %</td>
<td>27.50%</td>
<td>36.89%</td>
<td>40.00%</td>
<td>31.89%</td>
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<tr>
<td>Paper %</td>
<td>27.50%</td>
<td>36.89%</td>
<td>40.00%</td>
<td>8.11%</td>
</tr>
</tbody>
</table>
O'Hare Climate Analysis to Assess Feasibility of RAS in Asphalt Treated Permeable Base (ATPB) Layer
ATPB/RAS Mixture Considerations

• Asphalt Treated Permeable Base (ATPB)
  – Drainage layer
  – Provides no structural value
• Non-Optimal: Construction Delays
  – Temporary loss of working platform - ATPB tenderness
  – Crews wait 6-7 hours
• Including RAS
  – Stiff material
    • High PG grade
    • Contains fibers
  – Economic Incentive
    • Reduced waiting time
    • Reduced binder content

• Question: What percentage of RAS can be added such that significant thermal stresses do not build up, considering its position in the pavement (e.g., depth below surface)?
## Pavement Layers

<table>
<thead>
<tr>
<th>Layer</th>
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<tbody>
<tr>
<td>PCC</td>
</tr>
<tr>
<td>Runway Surface</td>
</tr>
<tr>
<td>Asphalt</td>
</tr>
<tr>
<td>Dense Grade Asphalt</td>
</tr>
<tr>
<td>Asphalt Treated Permeable Base</td>
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</tbody>
</table>
Enhanced Integrated Climate Model
Enhanced Integrated Climate Model
Low Temperature: 27.6°F (-2.4°C)
Climatic Analysis Findings/Current Recommendations

- Predicted temperatures at the top of the ATPB layer varied from 79.3°F to 27.6°F (26.3°C to -2.4°C)
- Implication: the effective Superpave asphalt binder grade (virgin binder + RAS binder) should be less than -2.4 C
- Since RAS is likely to have a PG Low Temperature Grade of PG XX-0 (+/- 10C), and ~ 50-60% binder replacement is anticipated in the ATPB mixture, a PG 64-22 virgin binder can be used for ATPB Mixture without cracking issues
- Binder and mixture testing is underway to pinpoint properties of this RAS source and the proposed mix
Binder and Mixture Testing to Support RAS ATPB Mix Design
Binder Extraction, Recovery, and Testing

- Recover RAS binder via Rotovap (AASHTO TP2)
  - Superpave binder testing
  - Fracture and acoustic emission (AE) testing
- RAS/Virgin binder
  - Meas. Effective PG grade
  - Fracture and AE testing
- Analysis/Modeling
  - Address FAA concerns
  - Develop practical system for future RAS mix designs to address low temp durability
Digital Image Correlation (DIC) Mixture Analysis

- Being developed as part of NSF study: UIUC-Road Science-NSF
- Allows analyst to ‘see’ strain and fracture development
- RAS – brittle? Effect of paper?
- DIC System
  - Canon EOS 5D Mark II, 21.1 MP
  - Image Acquisition Rate: 1 image/5 sec
  - 2144 pixels x 1544 pixels
DIC: HMA mix vs. Compacted 100% RAS

- HMA: 4.75mm NMAS, PG 64-22 binder
- DC(T) testing at -12 C
- Surprisingly, RAS ‘mixture’ had higher fracture energy than HMA (~900 J/m² vs. ~375 J/m²)
- However, premature to conclude that RAS will improve low temperature props of mix when used
- Paper/mastic effects creating ductile response?
DC(T) DIC $\varepsilon_{yy}$ (5 sec)

Recycled Asphalt Shingle

Hot Mix Asphalt

$e_y \times 10^{-6}$
DC(T) DIC $\varepsilon_{yy}$ (10 sec)

**Recycled Asphalt Shingle**

![Recycled Asphalt Shingle Graph](image1)

**Hot Mix Asphalt**

![Hot Mix Asphalt Graph](image2)
DC(T) DIC $\varepsilon_{yy}$ (15 sec)

Recycled Asphalt Shingle

Hot Mix Asphalt
Conclusions

• Foamed WMA mixes had good moisture resistance and borderline fracture resistance
• PG 64-22 binder is currently recommended for ATPB Mixture
• Binder and mixture testing of RAS mixtures will be available soon to validate this recommendation