National Center for Asphalt Technology
NCAT
at AUBURN UNIVERSITY
Research Update
October 6, 2010
Overview

- About NCAT
- NCHRP Projects
- Current Research Focus Areas
  - Warm Mix Asphalt
  - Increasing RAP Contents
  - The NCAT Test Track
- NCAT Outreach
NCAT History

- Established in 1986 through agreement with NAPA Research and Education Foundation and Auburn University
- The HMA industry raised $10,000,000 to establish an endowment fund for NCAT
- NCAT’s mission is to provide technical leadership for the asphalt paving industry through research and outreach.
NCAT Staff

- 33 full-time employees
  - 7 Ph.D. research engineers
  - 8 assistant research engineers
  - technicians, accountants, drivers, and office support
- 10-15 engineering student employees
- Collaboration with AU faculty researchers in a wide range of academic disciplines
NCAT Lead Researchers

Mr. Don Watson
Dr. Buzz Powell
Dr. Mike Heitzman
Dr. Randy West
Dr. David Timm
Dr. Nam Tran
Dr. Jaeseung Kim
Dr. Richard Willis
NCAT Facilities

- 40,000 ft² Office and Lab
  - 22,000 ft² laboratory space
  - 18,000 ft² educational and office space
- NCAT Test Track
  - 1.7 mile oval track with 46 pavement test sections
  - Accelerated loading via 5 heavily loaded triple-trailers
NCHRP Projects

Recently Completed Projects

- Superpave Ndesign Table
  - NCHRP Report 573
- Validating the Endurance Limit for HMA
  - NCHRP Report 646
- Mixing & Compaction Temperatures
  - NCHRP Report 648
NCHRP Projects

Ongoing Projects

– Improved Test Methods for Aggregate Specific Gravity and Absorption
– Engineering Properties, Emissions, and Field Performance of WMA Technologies
Warm Mix Asphalt
Warm Mix Asphalt

• WMA is asphalt mix produced with special technologies at temperatures 30 to 55°C lower than typical HMA

• Lower temperatures result in...
  • Less energy to produce asphalt mixes
  • Fewer emissions from asphalt plants
  • Less fumes and odors for paving crew and neighbors
  • Better workability at lower temperatures
NCHRP 9-47A Project Objectives

- Establish relationships between engineering properties of WMA to field performance
- Compare WMA to HMA
  - Performance
  - Construction practices
  - Emissions and fuel usage
  - Cost
TSR Preliminary Analyses

- < 240°F: TSR of WMA is significantly different (less) than HMA
- > 240°F: TSR of WMA is not significantly different than HMA
Hamburg Testing

- AASHTO T 324
  - No additional aging of plant mix
  - Twin molds
  - 50°C water bath
  - 10,000 cycles or to failure
  - Stripping inflection point, rut depth, and rutting rate
Hamburg: Stripping Inflection Point

![Graph showing stripping inflection point against compaction temperature. The x-axis represents compaction temperature in degrees Fahrenheit, ranging from 225 to 260, and the y-axis represents stripping inflection point in cycles, ranging from 0 to 12,000. Two sets of data are shown: HMA and WMA. The graph includes a red line indicating a threshold for stripping resistance.]
Hamburg Preliminary Analyses

- Most WMA mixes meet Hamburg SIP criteria even though the test was not required for mix approval
- Differences between WMA and HMA are not statistically significant
- Compaction temperature does not have a statistical effect on Hamburg results
APA

- AASHTO TP 63
- 6 cylindrical specimens
- Specimens compacted to 7±1% air voids
- Tested at high PG
- Air chamber
- Rut depth (manual and automated)
APA Rut Depths

![Graph showing APA Rut Depths](image)

**Compaction Temperature (°F)**

- 200°F
- 225°F
- 230°F
- 230°F
- 240°F
- 245°F
- 250°F
- 250°F
- 250°F
- 250°F
- 260°F

**Rut Depth (mm)**

- 0.0 mm
- 1.0 mm
- 2.0 mm
- 3.0 mm
- 4.0 mm
- 5.0 mm
- 6.0 mm
- 7.0 mm
- 8.0 mm

- **HMA**
- **WMA**
APA Preliminary Analyses

- Most WMA met a 5.5 mm rut depth criterion
- WMA often has a greater rut depth than the HMA
- < 240°F: WMA rut depths are significantly different (greater) than HMA rut depths
- > 240°F: Rut depths of WMA and HMA are not significantly different
- APA is known to be sensitive to binder stiffness
Increasing RAP Contents in Asphalt Mixtures
Why Recycle Asphalt?

- Economic Payoff
- Pavement Benefits
- Natural Resource Conservation
- Energy Savings / Carbon Footprint
Energy Consumption Related to Road Construction and Maint.

Source: The Environmental Road of the Future, Life Cycle Cost Analysis, Chappat and Bilal, Colas Group 2003, p.34
FHWA Recycling Expert Task Group

• Current state of practice for asphalt recycling
• Goal to increase average RAP content to 25% by 2013
• Identify barriers to effective RAP utilization
• Recommend research to address technical issues
Surface Mixes: % RAP Allowed

<table>
<thead>
<tr>
<th>% RAP Allowed</th>
<th>States</th>
</tr>
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<tbody>
<tr>
<td>0%</td>
<td>NY, NH</td>
</tr>
<tr>
<td>10%</td>
<td>CA, UT</td>
</tr>
<tr>
<td>15%</td>
<td>WI, IL</td>
</tr>
<tr>
<td>20%</td>
<td>IA, WI</td>
</tr>
<tr>
<td>25%</td>
<td>MO, IA</td>
</tr>
<tr>
<td>≥30%</td>
<td>OK, AR</td>
</tr>
<tr>
<td>n/a</td>
<td>Other</td>
</tr>
</tbody>
</table>

[Map showing the distribution of RAP allowed in different states]
Base Mixes: % RAP Allowed

The map shows the percentage of recycled asphalt pavement (RAP) allowed in different states. The colors range from 0% to ≥30%, with a 'n/a' for non-applicable areas.
Barriers to Increasing RAP

- Stockpile Management: 34%
- Long-term Performance: 18%
- Binder Issues: 13%
- Availability of RAP: 11%
- Other: 24%
RAP Management Best Practices

- RAP Needs Analysis
- Milling for Success
- Multiple-source RAP piles
- Crushing Considerations
- Screening Options
- Best Practices for Stockpiling
- Sampling and Testing of RAP Stockpiles
- Production of Recycled Asphalt Mixes
RAP Sampling & Testing Flowchart

At least 10 samples when building stockpile

Split each sample

Ignition method tests

Max. specific gravities

Gradations

Asphalt contents

Combine samples for other aggregate tests

Gse → Gsb
Summary & Analysis of RAP Data

- Calculate average and standard deviation of asphalt contents, gradations, and estimated Gsb
- Compare to the recommended tolerances

<table>
<thead>
<tr>
<th>RAP property</th>
<th>Max. Standard Deviation (%)</th>
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</thead>
<tbody>
<tr>
<td>Asphalt Content</td>
<td>0.5</td>
</tr>
<tr>
<td>% Passing Median Sieve</td>
<td>5.0</td>
</tr>
<tr>
<td>% Passing 75 micron Sieve</td>
<td>1.0</td>
</tr>
</tbody>
</table>
Barriers to Increasing RAP

- Stockpile Management: 34%
- Long-term Performance: 24%
- Binder Issues: 13%
- Availability of RAP: 11%
- Other: 18%
A Performance Comparison of RAP vs. Virgin Mixes

- LTPP SPS-5 pavement sections
- 18 U.S. states and Canadian provinces
- 500 ft. test sections
- Rehabilitated sections compare
  - 2” vs 5” overlay thickness
  - RAP (30%) vs virgin mixes
  - Milled vs unmilled surface preparation
- At least 30% RAP used in recycled mixes
- Projects range in age from 6 to 17 yrs
CONCLUSIONS

Based on the long-term performance of a large number of projects across North America...

- Pavements using ≥ 30% RAP are performing well, and in most cases, perform equal to or better than virgin pavements
- Transverse and fatigue cracking were observed more often in some pavements with RAP compared to pavements with all virgin materials
Findings & Recommendations

- Differences in cracking performance for several locations may have been due to higher dust contents and/or lower asphalt contents

- Lessons learned that impact high RAP content mix designs:
  - We need to pay attention to mix characteristics that affect resistance to cracking. Simple effects like dust contents and binder content (through VMA).
  - It is not clear whether or not using a softer virgin binder has an affect on cracking performance.
  - We should include some type of a cracking test during high RAP mix designs.
NCAT Pavement Test Track

- 1.7 mile oval asphalt track
- 45 experimental test sections, each 200 ft. long
- Test sections are sponsored by highway agencies and businesses to evaluate specific materials and/or pavement design strategies
- Realistic traffic applies 10 million ESALs in each two year cycle
- Currently 50% complete with the 4th cycle
Rutting Progression

- Coarse
- Fine
- Unmodified
- Modified

![Graph showing rutting progression against total traffic application (ESALs)]
Big Pay Offs for Track Research

- Revised Layer Coefficient for Pavement Design
  - 18% reduction in thickness for new pavements
- Good Performance of High RAP sections
- Fine and Coarse Superpave mixes perform similarly
- Validation of Perpetual Pavement Design
  - Field Endurance Limit: 90th percentile strain of 250 µε
Test Track Research Findings

- Dense-graded mixes perform as well as SMA
- Modified binders reduce rutting around 50%
- Lowering $N_{\text{design}}$ is O.K.

Criteria for Lab Performance Tests

- Air Voids
- Asphalt Pavement Analyzer
- Flow Number
- Top-Down Cracking
Test Track Research Findings

• Aggregate specification assessments
  – Elimination of Restricted Zone
  – F&E requirements for SMA & OGFC
  – Higher LA abrasion aggregates in SMA & Superpave
  – Polishing prone aggregates disqualified for surfaces
  – Gravel performs well in SMA & OGFC

• Porous Friction Course (OGFC) benefits
  – Dual layer
Test Track Research Findings

• Mechanistic pavement models validated and calibrated
  – Measured vs. predicted HMA tensile stresses
  – Compressive stresses in unbound layers
  – Pavement temperature models
  – Seasonal effects on pavement layers
  – Traffic wander
  – Transfer functions for strain damage
  – Speed vs strain / load pulse
Strain Instrumentation and Wireless Data Acquisition
N8 and N9 – Strain vs. Temperature

N8 Strain = 21.487e^{0.0335\cdot\text{Temperature}}
R^2 = 0.96

N9 Strain = 11.496e^{0.0298\cdot\text{Temperature}}
R^2 = 0.9217
The NCAT Test Track
The 4th Cycle
Current WMA Research

- New full-depth NCAT Test Track sections
- MeadWestvaco Evotherm DAT WMA
- Astec Foamed Asphalt WMA
- Control HMA
- 50% RAP+WMA
- Thiopave (Sulfur + WMA additive)
2009 Group Experiment

<table>
<thead>
<tr>
<th>Conventional Dense HMA</th>
<th>Permeable Surface on Dense HMA</th>
<th>High RAP % HMA</th>
<th>High RAP Warm Mix</th>
<th>Foamed Warm Mix</th>
<th>Additized Warm Mix</th>
<th>Thiopave Warm Sulfur</th>
<th>Thiopave Warm Sulfur</th>
<th>Kraton Modified Mix</th>
<th>TLA Modified Mix</th>
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</thead>
<tbody>
<tr>
<td>7 inches</td>
<td>7 inches</td>
<td>7 inches</td>
<td>7 inches</td>
<td>7 inches</td>
<td>7 inches</td>
<td>7 inches</td>
<td>9 inches</td>
<td>6.75 inches</td>
<td>7 inches</td>
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<tr>
<td>DGAB</td>
<td>DGAB</td>
<td>DGAB</td>
<td>DGAB</td>
<td>DGAB</td>
<td>DGAB</td>
<td>Control</td>
<td>Control</td>
<td>Control</td>
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</tr>
<tr>
<td>Stiff Subgrade</td>
<td>Stiff Subgrade</td>
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<td>Stiff Subgrade</td>
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</tr>
</tbody>
</table>

Private Sector Funding
Group Experiment – High RAP (N10 & N11)

- Control HMA Section
- 50% RAP Section
- 50% RAP WMA Section
Group Experiment – Warm Mix (S10 & S11)

![Graph showing the comparison of Foamed WMA Section, Control HMA Section, and Additive WMA Section against Mid-Depth Temperature, F. The x-axis represents the Mid-Depth Temperature in degrees Fahrenheit, while the y-axis shows the Longitudinal Microstrain. Different markers indicate distinct sections and conditions.]
Construction data for each section can be viewed by positioning your mouse over the section in question and left-clicking. Be sure and page-down to see all the data for multi-layered sections. The entire buildup is shown in structural sections, but only the upper (research) mixes are shown in sections with perpetual foundations.

- N1 through N11 and S8 through S12 are structural sections
- All other sections have deep perpetual foundations
- Research cycle of construction shown by color

Reconstruction of the 2009 experiment was completed in August of 2009 by East Alabama Paving, who was selected as the contractor via a competitive bidding process. The fourth research cycle again consists of extended traffic sections, new mix performance sections, and instrumented structural sections. The instrumented structural sections are part of a
NCAT Outreach
NCAT Outreach Components

- Communications
  - Website
  - Newsletter
  - Reports
  - Presentations
- Education & Training
  - Training courses
  - Courses for academic credit
  - Continuing education
  - Technology Transfer seminars
  - International Outreach

Our Outreach Goal is to better provide useful technical information that will help improve the life cycle cost of asphalt pavements.
Thank You

www.NCAT.us