NCAT Pavement Test Track

National Center for Asphalt Technology

Significant Findings
USA Today on 3/16/2011

- ND has third smallest population in US
  - Half the growth rate of the US average
- Lowest unemployment rate
  - Under 5 percent since 1987
- Greatest advance in per capita income
- $1B state budget surplus
  - $1B annual agricultural subsidies
  - Oil boom in western North Dakota
25 YEAR 1986 - 2011
National Center for Asphalt Technology
NCAT
at Auburn University
Current NCAT Research Areas

• High recycled content mixes
• Warm mix asphalt
• Pavement preservation
• Optimized structural design
• Alternative binder materials
• Drainable, quiet pavements
• Automated QC technologies
Accelerated Performance Testing
Test Track Layout
Thinner Structural Test Sections
Track Research Program

- Optimize pavement thickness design
- Identify ideal mixes, materials, methods, etc.
- Build-traffic$^2$-forensics in 3-year research cycles
Changes to Design Gradations

- **2000** – All mixes on coarse side of MDL
  - High design gyrations led to very dry mixes
  - Low durability resulted from poor compaction
- **2003** - Complete overhaul of methodology
  - Surface mixes required on fine side of MDL
  - Base and binder lifts optional coarse or fine
Changes to Mix Materials

- Optimized use of polymer binders
- Absorptive gravels in dense, SMA, OGFC
- Off network proof test for polishing
- Threshold properties for SMA aggregates
- High friction surface treatments
- Deicing aggregates in surface treatments
Changes to Design Gyrations

- 1998 - 139 gyration designs
- 2000 – 100 gyration designs
- 2003 – 80 gyration designs
- 2006 – 60 gyration designs
  - Via locking point (2 gyrations)
Low QC Air Voids, Neat AC, Ndes=60

Traffic Application (ESALs)

Average ARAN Rut Depth (mm)

S7A, S7B, S8A, S8B
Pavement Preservation

N4 – 9.5 mm NMA Grv/Lms/Sand

W6 – 4.75 mm NMA Lms/Grv/Sand

S6 – 12.5 mm NMA Grv/Lms/Sand
Comparable Performance
Thin Lift Laboratory Experiment

- Two screenings stockpiles identified (LMS & GRV)
- Blended 70/30 to match proven gradation in W6
- APA tests with binder contents at 6.0, 6.5, 7.0, & 7.5
- Control mixes are W6-like with both PG76 & PG67
Thin Lift Laboratory Experiment

- Two screenings stockpiles identified (LMS & GRV)
- Blended 70/30 to match proven gradation in W6
- APA tests with binder contents at 6.0, 6.5, 7.0, & 7.5
- Control mixes are W6-like with both PG76 & PG67
- Treatment mixes to target PG76-like performance:
  - Wool fibers
  - Thiopave sulfur pellets
  - Trinidad Lake Asphalt (TLA) pellets
  - iBind (in both PG67 and PG76)
Gradation Comparison

The image shows a graph comparing the percent passing of different sieve sizes for various materials. The graph plots sieve size on the x-axis and percent passing on the y-axis. Lines represent different materials and categories, with distinct colors and markers for each. The graph helps in comparing the gradation characteristics of different materials.
APA Rut Depths

![Graph showing APA Rut Depths](image-url)

- **Y-axis:** APA Manual Rut Depth After 8000 Cycles (mm)
- **X-axis:** Binder Content (%)

Legend:
- PG76
- PG76 + iBind
- PG67
- PG67 + iBind
- PG67 + Wool
- PG67 + Thiopave
- PG67 + TLA
- W6-2003

(Note: The image URL should be replaced with the actual URL of the graph image.)
GTR-Modified PG76-22

![Graph showing Average Rut Depth (mm) vs. Equivalent Single Axle Loadings (ESALs) for SBS and GTR materials.](image-url)
Perpetual Pavement on Soft Clay

• 14” pavement looks good after 17 million ESALs

• 10” pavement recently rehabilitated for 2\textsuperscript{nd} time
  – In need of 1\textsuperscript{st} rehabilitation after 10 million ESALs
  – 5” mill/inlay failed again after 3 ½ million ESALs
  – 2 ½ million ESALs on 5-3/4” high polymer inlay
Thin Perpetual Pavements

- 24 inch perpetual (original) Track foundation
  - Designed with ‘93 Guide for MANY cycles
- Two 9 inch thick structural sections in 2003
  - ‘93 Guide predicted failure near 10M ESALs
  - 27M ESALs to date (perpetual expectation)
- 15 inches of wasted (excess) thickness?
- 10 inches not enough on N8 soft subgrade
PG67 in 2006 High RAP Surfaces

- 7 section high RAP study (including control)
- 45% RAP with PG52, PG67, PG76, PG76s
- Cracking, raveling in PG76s section
- Minor cracking, raveling in PG76 section
- Similar performance in PG52 and PG67
Benefits of RAP

- Cost
- Quality
- Convenience
- Performance
RAP Economics

- Aggregate: $15/ton
- Asphalt: $500/ton
- Mix Design AC Content: 5%

\[
\begin{align*}
\text{Aggregate:} & \quad 15 \times 0.95 = 14.25 \\
\text{Asphalt:} & \quad 500 \times 0.05 = 25.00 \\
\text{Total Mix:} & \quad 14.25 + 25.00 = 39.25
\end{align*}
\]
RAP Economics

- Aggregate: $15/ton
- Asphalt: $500/ton
- RAP: $5/ton (5% AC in RAP)
- Mix Design
  - AC Content: 5%
  - RAP content 20% (19% rock, 1% AC)

\[
\begin{align*}
\text{Aggregate} & : 15 \times 0.76 = 11.40 \\
\text{Asphalt} & : 500 \times 0.04 = 20.00 \\
\text{RAP} & : 5 \times 0.20 = 1.00 \\
\text{Total Mix} & = 11.40 + 20.00 + 1.00 = 32.40
\end{align*}
\]
RAP Economics

- Virgin Mix: $39.25/ton
- Recycled Mix: $32.40/ton

@20% RAP, Savings = 17%
Fractionation
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>
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<th>Kraton Modified Mix</th>
<th>TLA Modified Mix</th>
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Private Sector Funding
Effective Asphalt Contents

![Bar graph showing effective asphalt contents for different sublots and binder types.](Diagram)
Gradations of 50% RAP Base/Binder
## 2009 Group Experiment (+)

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<td>9 inches</td>
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<td>6 inches DGAB</td>
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*Private Sector Funding*
WMA Technologies in the US

Shell Thiopave
MWV EVOtherm
PQ Corporation
ASTEC Industries, Inc.
Lea-co
Sasol
KOLO VEIDEME
TEREX
WMiA warmmixasphalt.com
MEEKER
EUROVIA
AkzoNobel
Gecabase rt
NEW WARM MIX
Benefits of WMA

• Lower energy cost
• Less binder hardening in plant
• Lower binder absorption into aggregate
• Reduced emissions (plant and roadway)
• Longer hauling distance
• Better compaction on roadway
• No field performance issues identified
2009 Group Experiment (+)

<table>
<thead>
<tr>
<th>Material</th>
<th>Average Rut Depth (mm)</th>
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<tbody>
<tr>
<td>Control Section</td>
<td>5.0</td>
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<tr>
<td>PFC Surface</td>
<td>4.6</td>
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<tr>
<td>RAP HMA</td>
<td>0.9</td>
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<tr>
<td>RAP WMA</td>
<td>2.5</td>
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<tr>
<td>Foam WMA</td>
<td>6.4</td>
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<tr>
<td>Add WMA</td>
<td>6.8</td>
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<tr>
<td>Thio Thick</td>
<td>5.9</td>
</tr>
<tr>
<td>Thio Std</td>
<td>5.6</td>
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<tr>
<td>Kraton Thin</td>
<td>1.7</td>
</tr>
<tr>
<td>TLA Std</td>
<td>3.9</td>
</tr>
</tbody>
</table>
“Volumetrics Plus” for WMA in 9-43

- Mixing/compaction °F via additive provider
- Lab foamers recommended (technology neutral)
- Compactability (N92comp-30F / N92comp ≤ 1.25)
- T283 (≥ 80 percent) and coating test for moisture
- FN with criteria as function of traffic
- Mix °F above PG grade of recycled materials
GE Strain Response

![Graph showing strain response](image)

Virgin Mixes

50% RAP
GE Strain Response

![Graph showing the relationship between mid-depth temperature and longitudinal microstrain for different sections with labels: N10, N11, S10, S11, S8, S9. There are clusters for Virgin Mixes and 50% RAP.]
GE Strain Response

Mid-Depth Temperature, F

Virgin Mixes

50% RAP

Longitudinal Microstrain

Section
- N10
- N11
- S10
- S11
- S8
- S9

Sum of T2

Sum of L
Performance Expectations
Benefits of RAP+WMA

- Minimizes blended binder aging (stiffness)
- Superheating eliminates baghouse condensation
- Ensures virgin aggregates are properly dried
- Allows plant production rate to increase
- Optimizes economic and environmental benefit
- RAP improves TSRs in WMA (some states require)
Indirect RAP Characterization

- Dynamic Modulus
- Bending Beam Rheometer
- Dynamic Shear Rheometer Torsion Bar
- Indirect Tension Relaxation Modulus
Performance data for each section can be viewed by positioning your mouse over the section in question and clicking. Based on feedback from our research sponsors, the performance reports have been revised to include crack maps. The 2009 performance reports are now a fully integrated and active part of the web presentation.
Web Performance Reports

<table>
<thead>
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<th>Quadrant:</th>
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<tbody>
<tr>
<td>Section:</td>
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</table>

### Surface Mix and Materials

- Year of Completion: 2006
- HMA Design Methodology: Superpave
- Specified Binder: PG76-22s
- Surface Mix Stockpile Materials: 25% M/R (45% RAP)
- Research Objective: RAP Mix Construction/Performance w/ Gasoil

### Structural Buildup Information

- Study HMA (in): 2
- Total HMA (in): 24
- Base Material: Granite
- Subgrade: 0"CC"

### Preliminary Field Performance Data

#### Equivalent Single Axle Loadings in 2009 Research Cycle

- **ARAN**
- **Dipstick**
- **ALDOT Gauge**
- **Wireline**

#### Crack Map (Trucking Percent Complete via Height of Gray Map Data Box)

- **Pre-Completion:**
  - **Transverse Offset (in):**
  - **Longitudinal Distance from Far Transverse Joint (feet):**

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*National Center for Asphalt Technology at Auburn University*
Questions ?