Key Findings from the NCAT Test Track

Dr. David Timm, P.E.
20th Annual NRRA Pavement Conference
Thursday, February 18, 2016
Test Track Overview

- Started operations in 2000
- 3-year Research Cycles
- 46 Test Sections, 200 ft. each
  - 26 sections in tangents
  - 20 sections in curves
- Test Sections are sponsored
- Increasing complexity over time
Test Track Timeline

2000
Surface Performance

2003
Mechanistic Models
Thickness Design
Structural Performance

2006
Perpetual Pavements

2009
Green Technologies

2012
CCPR Preservation

2015
Cracking
Outline

• General Findings
• Structural Studies
  – Structural Coefficient Recalibration
  – Perpetual Pavements
  – Cold Central Plant Recycling (CCPR)
• 2015 Test Track and MnROAD Partnership
General Findings – Mix Design

- Fine and coarse Superpave mixes perform similarly
- Modified binders cut rutting approximately 50%
- Dense-graded mixes perform as well as SMA for rutting resistance, but SMA is more durable
- Lowering $N_{\text{design}}$ is OK
General Findings - Aggregates

- Elimination of the Restricted Zone
- Limit polishing prone aggregates
- Allow gravel in SMA & OGFC
- Allow some F&E for SMA & OGFC
Structural Coefficient Calibration

- Current ALDOT pavement design based on AASHO Road Test

- Structural coefficients ($a_i$) are key inputs
  - Express relative “strength” of component layers
  - Used to determine required thicknesses of layers

- ALDOT asphalt coefficients were set in 1990
  - No changes since then
## AASHO HMA Coefficients

<table>
<thead>
<tr>
<th>Loop</th>
<th>Layer Coefficient ($a_1$)</th>
<th>Test Sections</th>
<th>$R^2$</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>0.83</td>
<td>44</td>
<td>0.80</td>
</tr>
<tr>
<td>3</td>
<td>0.44</td>
<td>60</td>
<td>0.83</td>
</tr>
<tr>
<td>4</td>
<td>0.44</td>
<td>60</td>
<td>0.90</td>
</tr>
<tr>
<td>5</td>
<td>0.47</td>
<td>60</td>
<td>0.92</td>
</tr>
<tr>
<td>6</td>
<td>0.33</td>
<td>60</td>
<td>0.81</td>
</tr>
</tbody>
</table>

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**Figure 9.** Automatic batch-type plant used to produce binder course mixtures; dryers in tandem.

**Figure 26.** During periods of adverse weather traffic operations were governed by safety considerations; snow and ice conditions usually resulted in operating at reduced speeds.

**Figure 1.** Looking east, Loops 5 and 2 in foreground.
### N1 – Predicted and Measured Traffic

**a₁ = 0.44 (R² = 0.08)**

<table>
<thead>
<tr>
<th>Predicted ESALs</th>
<th>Measured ESALs</th>
<th>Difference</th>
<th>% Error</th>
</tr>
</thead>
<tbody>
<tr>
<td>802,367</td>
<td>2,267,922</td>
<td>1,465,555</td>
<td>65%</td>
</tr>
<tr>
<td>1,126,574</td>
<td>2,837,091</td>
<td>1,710,517</td>
<td>60%</td>
</tr>
<tr>
<td>1,270,712</td>
<td>2,963,064</td>
<td>1,692,352</td>
<td>57%</td>
</tr>
<tr>
<td>1,638,661</td>
<td>3,212,141</td>
<td>1,573,480</td>
<td>49%</td>
</tr>
<tr>
<td>2,340,290</td>
<td>4,321,771</td>
<td>1,981,481</td>
<td>46%</td>
</tr>
</tbody>
</table>

**a₁ = 0.55 (R² = 0.74)**

<table>
<thead>
<tr>
<th>Predicted ESALs</th>
<th>Measured ESALs</th>
<th>Difference</th>
<th>% Error</th>
</tr>
</thead>
<tbody>
<tr>
<td>1,314,680</td>
<td>2,224,691</td>
<td>910012</td>
<td>41%</td>
</tr>
<tr>
<td>2,007,491</td>
<td>2,806,554</td>
<td>799065</td>
<td>28%</td>
</tr>
<tr>
<td>2,332,763</td>
<td>2,939,906</td>
<td>607145</td>
<td>21%</td>
</tr>
<tr>
<td>3,203,489</td>
<td>3,207,147</td>
<td>3661</td>
<td>0%</td>
</tr>
<tr>
<td>4,996,650</td>
<td>4,353,456</td>
<td>643194</td>
<td>15%</td>
</tr>
</tbody>
</table>
**a_1 Summary**

<table>
<thead>
<tr>
<th>Layer Coefficient</th>
<th>Layer</th>
<th>Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.50</td>
<td>N1</td>
<td>2003</td>
</tr>
<tr>
<td>0.59</td>
<td>N1</td>
<td>2006</td>
</tr>
<tr>
<td>0.56</td>
<td>N2</td>
<td>2003</td>
</tr>
<tr>
<td>0.63</td>
<td>N2</td>
<td>2006</td>
</tr>
<tr>
<td>0.62</td>
<td>N3</td>
<td>2003-2006</td>
</tr>
<tr>
<td>0.58</td>
<td>N4</td>
<td>2003-2006</td>
</tr>
<tr>
<td>0.58</td>
<td>N5</td>
<td>2006</td>
</tr>
<tr>
<td>0.59</td>
<td>N6</td>
<td>2003-2006</td>
</tr>
<tr>
<td>0.58</td>
<td>N7</td>
<td>2003-2006</td>
</tr>
<tr>
<td>0.43</td>
<td>N8</td>
<td>2003</td>
</tr>
<tr>
<td>0.48</td>
<td>N8</td>
<td>2006</td>
</tr>
<tr>
<td>0.48</td>
<td>N9</td>
<td>2006</td>
</tr>
<tr>
<td>0.44</td>
<td>N10</td>
<td>2006</td>
</tr>
<tr>
<td>0.41</td>
<td>N11</td>
<td>2006</td>
</tr>
<tr>
<td>0.68</td>
<td>Average</td>
<td>2003-2006</td>
</tr>
</tbody>
</table>

**Average Layer Coefficient:** 0.54
Effect on Pavement Design

Effect on Pavement Design

HMA Depth (in)

ESALs

1,000,000 10,000,000 100,000,000 1,000,000,000

18.5% Thinner

a1 = 0.44

a1 = 0.54

1,000,000 10,000,000 100,000,000 1,000,000,000
Structural Coefficient Implementation

- Not calibrated for thicknesses < 5”
  - ALDOT recommends 5” min thickness

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US Department of Transportation
Federal Highway Administration

Alabama Division

Mr. D. J. McInnes
Director
Alabama Department of Transportation
Montgomery, Alabama

Dear Mr. McInnes:

Please refer to Larry Lockett’s letter dated August 11, 2009, regarding a proposed increase in the Flexible Pavement Structural Coefficient. We have reviewed the National Center for Asphalt Technology (NCAT) research study and concur with the use of a structural coefficient of 0.54 per inch of thickness for bituminous plant mix binder layers, and wearing layers.

The NCAT research study did not include OGFC layers. The existing structural coefficient should be used for OGFC layers.

Please contact Steve Mills at (334) 223-6360 or Kristy Harris at (334) 223-6360 if you have any questions.

Sincerely yours,

[Signature]

for: Mark D. Bartlett, P. E.
Division Administrator
Perpetual Pavement Research
Perpetual Pavements at Test Track

• Sections N3 & N4
  – Built in 2003 as part of structural study
  – Expected to fail after 10 million ESAL
  – Have experienced 30 million ESAL
  – Excellent performance from both

• Sections N8 & N9
  – Built in 2006 as a perpetual experiment
  – 4 inch difference in AC depth with rich bottom
  – Drastic difference in section performance
N3 & N4

Depth from Pavement Surface, in.

N3 (PG 67-22)
- 1.2 Surface Mix
- 1.8 Upper Intermediate Mix
- 2.7 Lower Intermediate Mix
- 2.1 Upper Base Mix
- 1.3 Lower Base Mix
- 6 Aggregate Base

N4 (PG 76-22)
- 1 Surface Mix
- 1.7 Upper Intermediate Mix
- 2.3 Lower Intermediate Mix
- 1.8 Upper Base Mix
- 2 Lower Base Mix
- 6 Aggregate Base

Subgrade Soil
AC Modulus at 68°F

Average Backcalculated Modulus, ksi

<table>
<thead>
<tr>
<th>Section-Research Cycle</th>
<th>PG 67-22</th>
<th>PG 76-22</th>
<th>PG 67-22</th>
<th>PG 76-22</th>
</tr>
</thead>
<tbody>
<tr>
<td>N3-2003</td>
<td>700</td>
<td>800</td>
<td>700</td>
<td>900</td>
</tr>
<tr>
<td>N4-2003</td>
<td>750</td>
<td>850</td>
<td>750</td>
<td>950</td>
</tr>
<tr>
<td>N3-2009</td>
<td>720</td>
<td>820</td>
<td>720</td>
<td>920</td>
</tr>
<tr>
<td>N4-2009</td>
<td>780</td>
<td>880</td>
<td>780</td>
<td>980</td>
</tr>
</tbody>
</table>

12% increase
20% increase
Rutting Performance

Million Equivalent Single Axle Loads

Failure

Rut Depth, mm

Date

N3
N4
International Roughness Index

Failure

Million Equivalent Single Axle Loads

Date

International Roughness Index, m/km

N3

N4
13.5 Million ESALs
Section Performance - Rutting

2006 Test Track

2009 Test Track

- N8-non perpetual
- N9-perpetual

Rut Depth, mm

ESALs

HPM Mill & Inlay
Conventional Mill & Inlay with Fabric
Discount Rate = 2%

Initial Construction

32% Increase

Resurfacing

Conventional mill & inlay

HPM mill & inlay
Net Present Value

26% Savings

N8 (non-perpetual)

N9 (perpetual)
Strain Distributions for Perpetual Design

- No Fatigue
- Fatigue

Percentile vs. Microstrain graph with various data points and lines indicating different percentiles and years.
Cold Central Plant Recycling

- Milling
- Fractionation
- CCPR Mixing (RAP+binding agents)
- Conventional Paving
Cracking Performance

N3-6”AC

N4-4”AC

S12-4”AC SB
Ride Quality

Million ESAL

International Roughness Index, in./mile

Date


N3-6"AC
N4-4"AC
S12-4"AC SB
Tensile Strain vs Temperature

\[ y = 43.704e^{0.0263x} \]
\[ R^2 = 0.8179 \]

\[ y = 100.28e^{0.0217x} \]
\[ R^2 = 0.7159 \]

\[ y = 60.799e^{0.0117x} \]
\[ R^2 = 0.6544 \]
Results - $a_{CCPR}$

- $a_{CCPR} = 0.39$, $\sigma_{CCPR} = 0.13$
- $a_{CCPR} = 0.36$, $\sigma_{CCPR} = 0.06$

**N3-6'' AC**
- Linear equation: $y = -2E-05x + 1.1565$
- $R^2 = 0.001$

**N4-4'' AC**
- Linear equation: $y = 5E-05x - 1.6995$
- $R^2 = 0.036$
2015 Test Track – Major Research Areas

• Pavement Preservation
• Cracking Experiment
• Partnership with MnROAD
For more information on the NCAT Test Track...

ncat.us