Structural Pavement Studies at the NCAT Test Track

Rocky Mountain Asphalt Conference
February 24, 2010

Dr. David Timm, P.E.
Department of Civil Engineering – Auburn University

Sunday, March 28, 2010
Key Studies

• Re-calibration of asphalt structural coefficient
• Validation/Calibration of MEPDG
• Development of field-based endurance limit
• 2009 Test Track structural study
Re-Calibration of Asphalt Structural Coefficient

• 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

• Current ALDOT asphalt coefficients were officially set in 1990 ($a_1 = 0.44$)
  – No changes since then
2006 Test Sections

As Built Thickness, in.

- PG 67-22
- PG 76-22
- PG 76-22 (SMA)
- PG 76-28 (SMA)
- PG 76-28
- PG 64-22
- PG 64-22 (2% Air Voids)
- PG 70-22

Limerock Base  | Granite Base  | Type 5 Base  | Track Soil  | Seale Subgrade

Florida (new)  | Alabama & FHWA (left in-place)  | Oklahoma (new)  | Missouri (new)  | Alabama (new)

N1  | N2  | N3  | N4  | N5  | N6  | N7  | N8  | N9  | N10  | S11
N1 PSI vs Date

ΔPSI

Pt calibration points

Date

28-Jun-03 14-Jan-04 01-Aug-04 17-Feb-05 05-Sep-05 24-Mar-06

Sunday, March 28, 2010
a. Summary

Layer Coefficient

<table>
<thead>
<tr>
<th>Year</th>
<th>Layer Coefficient</th>
</tr>
</thead>
<tbody>
<tr>
<td>N1</td>
<td>0.50</td>
</tr>
<tr>
<td>N2</td>
<td>0.56</td>
</tr>
<tr>
<td>N3</td>
<td>0.63</td>
</tr>
<tr>
<td>N4</td>
<td>0.62</td>
</tr>
<tr>
<td>N5</td>
<td>0.58</td>
</tr>
<tr>
<td>N6</td>
<td>0.59</td>
</tr>
<tr>
<td>N7</td>
<td>0.58</td>
</tr>
<tr>
<td>N8</td>
<td>0.43</td>
</tr>
<tr>
<td>N9</td>
<td>0.48</td>
</tr>
<tr>
<td>N10</td>
<td>0.44</td>
</tr>
<tr>
<td>S11</td>
<td>0.41</td>
</tr>
<tr>
<td>Average</td>
<td>0.54</td>
</tr>
</tbody>
</table>
Effect on Pavement Design

- 18.5% Thinner

Sunday, March 28, 2010
STRUCTURAL COEFFICIENT STATUS

September 10, 2009

MEMORANDUM

TO: Mr. Johnny Harris, P. E.
    Mr. James D. Brown, P. E.
    Mr. Brian Davis, P. E.
    Mr. DelJarvis Leonard, P. E.
    Ms. L. Dee Rowe, P. E.

FROM: Larry Lockett, P. E.
       Materials and Tests Engineer

RE: 0.54 Layer Coefficient

Pursuant to structural experiments/studies performed in 2003 and 2006 at the National Center for Asphalt Technology (NCAT) test track facility, effective with the January 2010 transportation letting, a layer coefficient of 0.54 per inch of thickness shall be applied to the structural design of bituminous plant mix binder layers and bituminous plant mix wearing layers on new construction (non-resurfacing) projects. The 0.54 layer coefficient WILL NOT apply to Section 420, Polymer Modified Open Graded Friction Course, since this mix was not included in the aforementioned NCAT structural experiments/studies. The layer coefficient for Section 420 will remain at the previously assigned value of 0.44 per inch of thickness, with the layer thickness typically being one inch, when this material is approved for use on a project.

The 0.54 layer coefficient is already being applied to the falling weight deflectometer (FWD) analysis of the Phase 1 resurfacing projects for 2010. With regards to new construction (non-resurfacing) projects, any project that already has an approved materials report on file will require an addendum to update the pavement structural design for the project to the new 0.54 layer coefficient; if the project is going to be let to contract in January 2010 or thereafter, however, the use of the 0.54 layer coefficient may be waived if the resulting structural design will necessitate extensive plan revisions.

The use of the 0.54 layer coefficient per inch of thickness for bituminous plant mix binder layers and wearing layers was formally approved by the Federal Highway Administration on September 10, 2009.
More Information…

www.ncat.us
Validation/Calibration of MEPDG
MEPDG Inputs

N1_2006 - Mechanistic Empirical Pavement Design Guide

Project (C:\Kendra\Projects\Calibration-Validation\N1_2006.dgp)

- General Information
- Site/Project Identification
- Analysis Parameters

Inputs
- Traffic
  - Traffic Volume Adjustment Factors
  - Monthly Adjustment
  - Vehicle Class Distribution
  - Hourly Truck Distribution
  - Traffic Growth Factor
  - Axle Load Distribution Factors
- General Traffic Inputs
  - Number Axles/Truck
  - Axle Configuration
  - Wheelbase
- Climate
- Structure
  - HMA Design Properties
- Layers
  - Layer 1 - Asphalt concrete
  - Layer 2 - Asphalt concrete
  - Layer 3 - Asphalt concrete
  - Layer 4 - Crushed stone
  - Layer 5 - A-4
- Thermal Cracking

Results
- Input Summary
- Output Summary
- Flexible Summary
- Layer Modulus
- AC Modulus (plot)
- Fatigue Cracking
- Surface Down Damage (plot)
- Surface Down Cracking (plot)
- Bottom Up Damage (plot)
- Bottom Up Cracking (plot)
- Thermal Cracking
- Crack Depth (plot)
- Thermal (C-h) (plot)
- Crack Length (plot)
- Crack Spacing (plot)
- Rutting
- Rutting (plot)
- IRI (plot)

Analysis Status:
- Traffic: 100%
- Climatic: 100%
- Thermal Cracking: 100%
- AC Analysis: 100%
- Summary: 100%

General Project Information:
- Type: New Flexible
- Design Life: 2 Years
- Climate: C:\Kendra\Projects\Calibration-Validation\N1_2006.dgp
- Construction Date: 9/2006

Properties
- Setting: Value
  - Units: US Customary
  - Analysis Type: Probabilistic
  - Output Type: Excel Worksheet
  - Warnings: Enabled

Run Analysis

Sunday, March 28, 2010
MEPDG Inputs
MEPDG Inputs
N8 Rutting

![Graph showing rut depth over time with measured and predicted data points.](image-url)
Rutting Measured vs. Predicted

Sunday, March 28, 2010
IRI Measured vs. Predicted

Sunday, March 28, 2010
Measured and Predicted Cracking
Development of Field-Based Endurance Limit
Study Overview

• Sections from 2000, 2003 and 2006 Test Track
  – Included both cracked and uncracked
• Simulated (2000) and measured (2003 and 2006) strains
• Laboratory beam fatigue testing
• Related field strain levels to lab field levels
• Distinguished between sections as function of strain ratio

\[ R_f = \frac{\varepsilon_{field}}{\varepsilon_{lab}} \]

• Developed fatigue design curve
Strain and Temperature

The graph shows the longitudinal microstrain and temperature over time for N8 and N9. The horizontal axis represents the dates from November 1, 2006, to April 24, 2008. The vertical axis on the left shows longitudinal microstrain, while the vertical axis on the right shows mid-depth pavement temperature in degrees Fahrenheit. The graph indicates fluctuating patterns in both strain and temperature over time.
Strain vs. Temperature

<table>
<thead>
<tr>
<th>Section</th>
<th>Axle Type</th>
<th>$C_1$</th>
<th>$C_2$</th>
<th>$R^2$</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Single</td>
<td>21.249</td>
<td>0.033</td>
<td>0.96</td>
</tr>
<tr>
<td>N8</td>
<td>Tandem</td>
<td>15.326</td>
<td>0.035</td>
<td>0.96</td>
</tr>
<tr>
<td></td>
<td>Steer</td>
<td>11.341</td>
<td>0.036</td>
<td>0.87</td>
</tr>
<tr>
<td></td>
<td>Single</td>
<td>11.136</td>
<td>0.029</td>
<td>0.93</td>
</tr>
<tr>
<td>N9</td>
<td>Tandem</td>
<td>8.600</td>
<td>0.030</td>
<td>0.92</td>
</tr>
<tr>
<td></td>
<td>Steer</td>
<td>5.901</td>
<td>0.030</td>
<td>0.93</td>
</tr>
</tbody>
</table>

N8 Strain = $21.249e^{0.033*Temp}$
$R^2 = 0.9584$

N9 Strain = $11.136e^{0.029*Temp}$
$R^2 = 0.9309$
Strain Distributions

![Strain Distributions Graph](image)

- **Percentile**
  - 100%
  - 90%
  - 80%
  - 70%
  - 60%
  - 50%
  - 40%
  - 30%
  - 20%
  - 10%
  - 0%

- **Longitudinal Strain**
  - 0
  - 100
  - 200
  - 300
  - 400
  - 500
  - 600
  - 700
  - 800
  - 900
  - 1000
  - 1100
  - 1200

- **Graph Lines**
  - Black Line: N9
  - Orange Line: N8

Sunday, March 28, 2010
2003 Test Sections

Sunday, March 28, 2010
Fatigue Cracking Occurred

Sunday, March 28, 2010
2003 Test Sections

Fatigue Cracking Occurred

Fatigue Cracking Absent

Max Ratio = 2.11
2006 Test Sections

Fatigue Cracking Occurred

Fatigue Cracking Absent
Max. Ratio = 2.18
2009 Test Track

Sunday, March 28, 2010
Data Collection

• High Speed
  – Weekly
  – 3 passes of each truck on each section

• Slow Speed
  – 1 reading/minute
  – Hourly summary

• Performance
  – Weekly
    • Rut depth
    • Cracking
Preliminary Results

Sunday, March 28, 2010
Average Longitudinal MicroStrain at 70F

- FL-M/I Spray
- FL-M/I Control
- Thiopave-9"
- Thiopave-7"
- Kraton-5.75"
- OK-10"
- OK-14"
- 50% RAP
- 50% RAP WMA
- OGFC
- Control
- WMA-Foam
- WMA-Additive
- Trinidad Lake Asphalt

Sunday, March 28, 2010
Thank you!

More Information:
www.pavetrack.com

Sunday, March 28, 2010