Topics

- TWPD (NCAT Three Wheel Polishing Device)
- DFT (Dynamic Friction Tester)
- DOT Mix Lab Study
- High Friction Surface Treatment (HFST)
- NCAT Test Track Results
TWPD Development
Problem Statement

- Friction aggregate is the costly, premier aggregate product in the mix.
- Early research assessed the coarse friction aggregate independent of the mix.
- Specification criteria are based on conservative engineering judgment from a limited number of field trials.
- Friction studies require lengthy field trials.
NCAT Three Wheel Polishing Device

Motor

Counter

Water Tank

Load

Pneumatic Tires

HMA Slab
Preparing Mix Slabs
Test Protocol

- Test two replicate slabs
- 0-0.5-1-2-5-10-20-40-60-100K cumulative polishing cycles
Dynamic Friction Tester (DFT)

• Tests conducted at specific intervals during polishing (0, 0.5, 1, 2, 5, 10….100k cycles).
• Three replicate measurements.
• Friction values are measured at 0, 20, 40, 60 and 80 km/h.
• Test Procedure ASTM E 1911
DFT Output
Use of Test Track Mixtures

FHWA Friction Study - Test Track Field Performance

- E1 2003 TN hard
- W7 2000 AL soft
- N4 2003 AL hard
- W3 2003 SC soft

Test Track Loading (ESALs) vs. SN40

[Chart showing the performance of different test track mixtures under varying loadings.]

- SN40 values range from 0 to 60.
- Test track loading ranges from 1,000,000 to 10,000,000 ESALs.
Friction Ranking Based on Lab & Track Results

<table>
<thead>
<tr>
<th>Mix Type</th>
<th>Ranking based on</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Laboratory Results</td>
</tr>
<tr>
<td>E1</td>
<td>1</td>
</tr>
<tr>
<td>W7</td>
<td>2</td>
</tr>
<tr>
<td>N4</td>
<td>3</td>
</tr>
<tr>
<td>W3</td>
<td>4</td>
</tr>
</tbody>
</table>

Graphs showing comparison of Avg. DFT - 9# load - 60 rpm speed over Conditioning Cycles and Test Track Loading (ESALs) for different mix types: E1 Mix, N4 Mix, W3 Mix, and W7 Mix.
**Lab and Test Track Data Correlation**

<table>
<thead>
<tr>
<th>Mix Type</th>
<th>Model</th>
<th>ANOVA Table</th>
<th>R-square, %</th>
<th>Pearson's Correlation Coefficient</th>
</tr>
</thead>
<tbody>
<tr>
<td>E1 mix</td>
<td>( SN64 = 20.3 + 0.582 \text{ DFT}_{60} )</td>
<td>59.34</td>
<td>0.016</td>
<td>96.7</td>
</tr>
<tr>
<td>W7 mix</td>
<td>( SN64 = -4.6 + 0.878 \text{ DFT}_{60} )</td>
<td>7.93</td>
<td>0.106</td>
<td>79.9</td>
</tr>
<tr>
<td>N4 mix</td>
<td>( SN64 = -0.3 + 0.927 \text{ DFT}_{60} )</td>
<td>2.65</td>
<td>0.245</td>
<td>57.0</td>
</tr>
<tr>
<td>W3 mix</td>
<td>( SN64 = -44.0 + 1.97 \text{ DFT}_{60} )</td>
<td>2.00</td>
<td>0.293</td>
<td>50.0</td>
</tr>
</tbody>
</table>

The graph shows the relationship between SN64 and DFT\(_{60}\) with a linear trendline and points representing the data. The equation for the best fit line is \( SN64 = -19.43 + 1.36 \text{ DFT}_{60} \times 100 \) with an \( R^2 = 0.9531 \).
MS DOT Study Objective

Use the NCAT rapid laboratory friction evaluation test protocol with the TWPD conditioning and DFT testing devices to better understand the influence of friction aggregate in a typical gravel-limestone 9.5 mm surface mixture and in an ultra-thin surface mixture (4.75 mm).
9.5 mm Mixture and Aggregate Substitutions

1. Identify 9.5 mm mixture
   - 65% crushed gravel (50% +No.8)
   - 24% limestone (8% +No.8)
   - 10% sand

2. Determine the coarse aggregate substitutions (+No.8)
   - 33% & 60% slag
   - 33 % & 60% granite

3. Screen the source gradations for blending (split on No.8)

4. Prepare three replicate test slabs of each mix with PG 67 -22 binder compacted to 7% air voids
9.5 mm Mixture Results - DFT

Average Fn @ 40 kph

conditioning cycles

Avg Fn

Control  33% Slag  60% Slag  33% Granite  60% Granite
1. Identify ultra-thin mixture
   • 70% limestone
   • 10% natural sand
   • 19% manufactured sand
2. Determine the total aggregate substitutions
   • 25% & 50% crushed gravel
3. Screen the source gradations for blending (split on No.16)
4. Prepare three replicate test slabs with PG67-22 binder compacted to 7% air voids
Ultra-thin Mixture Results - DFT

Average Fn @ 40 kph

- Control
- 25% Crushed Gravel
- 50% Crushed Gravel
HFST Research Program

- Lab-1 Study (8 aggregates)
  - TWPD conditioning, DFT/CTM measurements
- Field Study (8 aggregates, extended for 3 aggrs)
  - Test Track truck conditioning
  - DFT/CTM measurements
  - Skid Trailer measurements
- Lab-2 Study (4 aggregates)
  - Aggr Size? #8 & #12, some #6 & #16
  - TWPD conditioning, DFT/CTM testing
  - British Pendulum
  - Micro-Deval, AIMS
Lab Polishing
W9F - Taconite, MN
W9E – Al-Fe Oxide, OR
W9D – Slag, PA
W9C – Silica, OH
W9B – Basalt, WA
W9A – Chert, OK
W8B – Bauxite, China
W8A – Granite, WI
SN40R to DFT(40) Correlation

\[ y = 77.385x + 3.3428 \]
\[ R^2 = 0.9911 \]

\[ y = 92.322x - 13.871 \]
\[ R^2 = 0.9971 \]
Friction Ranking

HFS Aggregate Type

- Field DFT
- Lab-1 DFT
- Field Skid
- Field Skid (projected)
- Field Skid projected (Slag-2)
Test Track Friction Results

Test variation
• SMA mixes
• Asphalt binder comparison
• PFC mixes
Binders Comparison

SN40R

Sep-12 Jan-13 May-13 Sep-13 Jan-14 May-14 Sep-14

Mod-1 blue, Mod-2 red, Mod-3 green
Thank you. Questions?

Mike Heitzman
mah0016@auburn.edu
www.ncat.us