Mizzou/MAPIL Update

by

Bill Buttlar, Glen Barton Chair in Flexible Pavements

January 8, 2020

MAPA Annual Conference
Outline

• Highlighted Research Project: MAPIL-MoDOT ‘Support for Balanced Mix Design in MO’

• What can MAPIL do for You

• And now, announcing…
Highlighted Research Project:

MAPIL-MoDOT ‘Support for Balanced Mix Design in MO’
Background/challenges

- SHRP fell short in delivering mix performance test to supplement volumetric design
- Current asphalt mixture design are primarily based on volumetrics
- Inclusion of modern recycling methods is challenging in current binder and volumetrics specs

Balanced Mix Design (BMD), or Performance - Engineered Mixture Design (PEMD)
Why ‘Performance – based’ Specs?

- Tests the “End result” of a mixture design. **Binder, aggregate, blending, aging, interactions…all captured.**
  
- Allow innovative volumetric combinations of aggregates, binders and other additives (RAP, RAS, GTR, rejuvenators, fibers etc.) while controlling cracking, rutting, and stripping

- Promotion of contractor innovation to keep cost down and boost mix performance
Development of Pavement Temperature Maps

- Analyze continuous PG grade for Missouri
- More precise testing temperature at any location (DC(T), Hamburg Wheel, iFIT, IDEAL)

Low pav. temperature
98% reliability
PG : -28 and -22

What about temperatures closer to -24°C or -26°C?
High pavement temperature 98% reliability

CONTINUOUS PG HIGH TEMPERATURE 98% RELIABILITY h= 0mm

CONTINUOUS PG HIGH TEMPERATURE 98% RELIABILITY h=25 mm

Pav. T at surface

Pav. T at h=25 mm depth
Contour map Missouri – Low Temp

Continuous PG low temperature for h=0 mm 98% reliability
Performance Testing on Asphalt Mixtures at Multiple Temperatures

DC(T) and HWTT
## Experimental program

<table>
<thead>
<tr>
<th>Mixtures</th>
<th>Hamburg wheel test temperature °C</th>
<th>DC(T) fracture test temperature °C</th>
</tr>
</thead>
<tbody>
<tr>
<td>US63_1</td>
<td>40, 46, 52, 58, 64</td>
<td>-3, -6, -9, -12, -18</td>
</tr>
<tr>
<td>MO13_1</td>
<td>46, 52, 58</td>
<td>-6, -9, -12, -18</td>
</tr>
<tr>
<td>US54_1</td>
<td>46, 52, 58</td>
<td>-6, -9, -12, -18</td>
</tr>
<tr>
<td>US54_6</td>
<td>52, 58</td>
<td>-6, -9, -12</td>
</tr>
<tr>
<td>TRO_L</td>
<td>40, 46, 50, 58</td>
<td>-3, -6, -9, -12, -18, -24</td>
</tr>
<tr>
<td>TRO_L10R</td>
<td>40, 46, 50, 58, 64</td>
<td>-3, -6, -9, -12, -18, -24</td>
</tr>
<tr>
<td>OK_70P</td>
<td>46, 50, 58, 64</td>
<td>-12, -24</td>
</tr>
<tr>
<td>OK_70P5</td>
<td>40, 46, 50, 58, 64</td>
<td>-12, -18, -24</td>
</tr>
<tr>
<td>ACE_PM</td>
<td>40, 46, 50, 58</td>
<td>-3, -6, -9, -12, -18</td>
</tr>
<tr>
<td>ACE_CM</td>
<td>40, 50, 55</td>
<td>-12, -18, -24</td>
</tr>
<tr>
<td>ACE_FM</td>
<td>50, 58</td>
<td>-12, -18</td>
</tr>
</tbody>
</table>

HWTT: 160 specimens (2 wheel passes each temperature)  
DC(T): 129 specimens (3 replicates each temperature)
DC(T) results

Fracture Energy [J/m²]

-24°C
-18°C
-12°C
-9°C
-6°C
-3°C

US63_1  MO13_1  US54_1  US54_6  TRO_L  TRO_L10R  OK_70P  OK_70P5

Lab mixes
Plant mix - Lab compacted

High traffic level
Moderate traffic level
Low traffic level
HWTT test results

Group A

Plant - Lab compacted mixtures

Mixtures paved on 2016

Wheel passes vs. Rut depth curves
Group B: Rubber modified mixtures

- TROL: Control lab mix
- TRO_LR10: Lab mix (10% rubber)
- OK_70P: Plant control mixture
- OK_70P5: Plant modified mixture (5% rubber)

Wheel passes vs. Rut depth curves
Conclusions-Performance testing results

- DC(T)
  - As temperature increases, fracture energy increases
  - Fracture energy results are highly influenced by test temperature
    A variation of 25J/m² is high enough to cause damage or crack on asphalt mixtures according to researchers in Minnesota (Hoplin, 2016).

- HWTT
  - Most of mixtures presented showed significant increase in rutting and fail criteria when tested at temperature above 50°C (55°C, 58°C and 64 °C)
  - Rutting depth results are highly influenced by the test temperature, as the temperature increases the deformation increases

Testing Temperature selection is important !!!
Tailored test temperatures across Missouri are recommended, and tailoring for lift locations below surface, and shoulders.
IDEAL – iFIT Correlation

IDEAL vs FI

\[ y = 18.482x^{0.8719} \]

\[ R^2 = 0.8719 \]
**Aging Effect on Cracking Tests - DCT**

**IL Tollway Study – 6 days loose mix long-term aging (LTA) at 95°C**

- **Gf (STA)**
  - 1835
  - 772
- **Gf (LTA)**
  - 1836
  - 596
  - 427
- **ABR by RAP**
  - 1818
  - 25.0
  - 16.2
  - 20.4
- **ABR by RAS**
  - 64.34
  - 16.1
  - 16.3
  - 0.0
- **Total ABR**
  - 41.2
  - 32.5
  - 20.4

**DC(T) Fracture Energy (J/m²) at -12 ℃**

- SMA F. S.
  - SMA S. SBS
  - 3% increase!
  - SMA S. SBS
  - 19% drop
  - Shoulder S.
  - 17% drop
Aging Effect on Cracking Tests - iFIT

IL Tollway Study – 6 days loose mix long-term aging (LTA) at 95°C
MoDOT Current Balanced Mix design specification

**Future Work**

Hamburg Wheel Tracking Test

<table>
<thead>
<tr>
<th>PG Grade High Temperature *</th>
<th>Minimum Wheel Passes</th>
<th>Maximum Rut Depth (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>58S-xx</td>
<td>5,000</td>
<td>12.5</td>
</tr>
<tr>
<td>64S-22</td>
<td>7,500</td>
<td>12.5</td>
</tr>
<tr>
<td>64H-22</td>
<td>15,000</td>
<td>12.5</td>
</tr>
<tr>
<td>64V-22</td>
<td>20,000</td>
<td>12.5</td>
</tr>
</tbody>
</table>

*Detected by the binder grade specified in the contract

Extension of the spec. to binder course mixtures
Continue aging studies, including storage and reheating
Future Work

MoDOT Current Balanced Mix design specification

<table>
<thead>
<tr>
<th>FLEXIBILITY INDEX</th>
<th>Ideal CT</th>
<th>Percent of Contract</th>
</tr>
</thead>
<tbody>
<tr>
<td>NMAS &lt;190</td>
<td>NMAS &lt;190</td>
<td>Price</td>
</tr>
<tr>
<td>&lt; 2.0</td>
<td>&lt; 32</td>
<td>98%</td>
</tr>
<tr>
<td>2.0 – 3.9</td>
<td>32 – 60</td>
<td>100%</td>
</tr>
<tr>
<td>4.0 – 7.9</td>
<td>60 - 97</td>
<td>102%</td>
</tr>
<tr>
<td>&gt;8.0</td>
<td>&gt; 97</td>
<td>103%</td>
</tr>
</tbody>
</table>

Intermediate temperature \( IT = \frac{HT + LT}{2} \)

\[ IT = \frac{60 + (-24)}{2} = 18 \]

\[ IT = \frac{64 + (-20)}{2} = 22 \]

Adjustment of the spec. to intermediate temperature

I-FIT
50 mm/min
25°C

IDEAL-CT
50 mm/min
25°C
What can MAPIL do for You?

- Superpave Binder and Mixture Testing
- Mixture design
- Mixture Tune-ups and Optimization
- ‘Fix-the-Mix’
- Binder Grading and Mixture Grading (new)
- Binder Extraction and Recovery
- Advanced Testing, Modeling, Sensors….

[www.MAPIL.Missouri.edu](http://www.MAPIL.Missouri.edu)
And now, Announcing....
Missouri Center for Transportation Innovation (MCTI)

Partnership with the University of Missouri System and MoDOT, in cooperation with FHWA, other universities and transportation professionals.

MCTI Grand Opening
December 17, 2019
Jefferson City
Goals of the Center

- Identify, conduct and disseminate research
- Complete practical, timely, and implementable research
- Implement innovative technologies
- Increase Missouri’s participation and influence in national research
- Produce future transportation engineers
- Create an atmosphere that develops faculty and staff at the University and MoDOT
Existing Laboratory Facilities will be Utilized Including MoDOT’s Central Lab & Envisioned I-70 Test Road
Organizational Framework

- Performance Committee
  - State CM Engineer
  - Research Administrative Engineer
  - MoDOT District Engineer
  - FHWA Transportation Engineer
  - University Deans (or designees)
Organizational Framework (cont.)

- Center Operations Cabinet
  - Center Director (Bill Buttlar - MU) and Deputy Director (John Myers – S&T)
  - UM System Lead Faculty (Jill Bernard-Bracy - UMSL; John Kevern - UMKC)
  - MoDOT Research Lead (Jen Harper)
  - MCTI Core Staff

- Technical Advisory Groups
  - Comprised of multiple organizations based on focus areas

- Principal Investigators
  - Successful Proposals Selected by MoDOT
Focus Areas

- Design & Construction Administration
- Geotechnical
- Environmental and Hydraulics
- Maintenance
- Multimodal (Aviation, Transit, Rail, Ports)
- Pavements
- Structures
- System & Data Analytics
- Traffic Engineering and Safety
Technical Advisory Groups (TAGs)

MoDOT and MCTI establish TAGs consisting of:

- MoDOT
- University
- FHWA
- Local Agencies
- Consultants
- Industry
- MoSTIC members
- Other Governmental Agencies

Volunteer to Serve Today!!!
Research to Practice

- A final presentation will be scheduled with applicable MoDOT staff that are instrumental in implementation

- MoDOT executes the research implementation plan with assistance from MCTI
Technology Transfer

- MCTI Sponsored Conferences

- Communication of Research
  - Center website
  - Presentations and webinars
  - Journal publications
Thank you!

Bill Buttlar, PhD, PE
Director
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