Asphalt Pavement Research Trends

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Current / Future Focus Areas

• Mechanistic Design
  – AASHTO MEPDG
• The Environment
  – Energy, Emissions & Noise
• Safety
  – Friction and tire-surface interaction
• Superior Materials
  – Modified Binders
  – Micro-mechanics, Imaging & Visualization to learn
AASHTO MEPDG

**Fully Integrated Design Software**

- Traffic
- Environment
- Structure
- Mix Design
- PG Grading
- Pavement Distresses
You can enter changes in gradation, and estimate changes in performance.
You can enter changes in PG grading, and estimate changes in performance.
You can enter changes in subgrade and base, and estimate changes in performance.
## Performance Criteria

<table>
<thead>
<tr>
<th>Performance Criteria</th>
<th>Distress Target</th>
<th>Distress Predicted</th>
<th>Reliability Predicted</th>
<th>Acceptable</th>
</tr>
</thead>
<tbody>
<tr>
<td>Terminal IRI (in/mi)</td>
<td>172</td>
<td>104.1</td>
<td>98.9</td>
<td>Pass</td>
</tr>
<tr>
<td>AC Bottom Up Cracking (Alligator Cracking) (%)</td>
<td>25</td>
<td>4.9</td>
<td>92.2</td>
<td>Pass</td>
</tr>
<tr>
<td>AC Thermal Fracture (Transverse Cracking) (ft/mi)</td>
<td>1000</td>
<td>74.8</td>
<td>99.9</td>
<td>Pass</td>
</tr>
<tr>
<td>Permanent Deformation- AC Only (AC Only) (in)</td>
<td>0.25</td>
<td>0.21</td>
<td>71.1</td>
<td>Fail</td>
</tr>
<tr>
<td>Permanent Deformation – All Layers (Total Pavement) (in):</td>
<td>0.75</td>
<td>0.65</td>
<td>81.6</td>
<td>Fail</td>
</tr>
</tbody>
</table>
## Output Example - PG 76-22

<table>
<thead>
<tr>
<th>Performance Criteria</th>
<th>Distress Target</th>
<th>Distress Predicted</th>
<th>Reliability Predicted</th>
<th>Acceptable</th>
</tr>
</thead>
<tbody>
<tr>
<td>Terminal IRI (in/mi)</td>
<td>172</td>
<td>90</td>
<td>99.3</td>
<td>Pass</td>
</tr>
<tr>
<td>AC Bottom Up Cracking (Alligator Cracking) (%)</td>
<td>25</td>
<td>4.9</td>
<td>92.8</td>
<td>Pass</td>
</tr>
<tr>
<td>AC Thermal Fracture (Transverse Cracking) (ft/mi):</td>
<td>1000</td>
<td>74.8</td>
<td>99.9</td>
<td>Pass</td>
</tr>
<tr>
<td>Permanent Deformation- AC Only (AC Only) (in):</td>
<td>0.25</td>
<td>0.17</td>
<td>90.6</td>
<td>Pass</td>
</tr>
<tr>
<td>Permanent Deformation – All Layers (Total Pavement) (in):</td>
<td>0.75</td>
<td>0.61</td>
<td>92.2</td>
<td>Pass</td>
</tr>
</tbody>
</table>
The Environment (Sustainable Roads)

• Asphalt is one of the most sustainable construction materials

• The next few years will quantify this for designers and specifiers of roads
  – Increased recycling by design
  – Reduce energy and emissions
    • Warm mix practice
  – Quiet roads by design of surface texture
Distribution of Energy Consumption
Asphalt Roads

Total Energy Consumed (%)

- Material Extraction: 1.8%
- Manufacturing: 91.7%
- Placement: 6.7%
Current Practice: Focus on materials’ initial cost
Future Practice: Focus on profit from reduced energy and lower emissions

Source: Image used courtesy of Payne & Dolan
Evolving Estimation & Analysis Tools

• Pavement Life-cycle Assessment Test for Environment and Economic Effects (PaLATE)

• Plant Diagnostic and Optimization Tool
  – Pennsylvania Asphalt Pavement Association (PAPA)

• Spreadsheet models for Energy and Emissions
  – World Bank
  – Land Transport New Zealand
Existing Tools: PaLATE
Pavement Life Cycle Analysis for Environment and Economic effects

Instructions: Design

Design → Materials Production → Construction → Used → Operation → Maintenance

Only fill in the appropriate cells

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Wearing Course 1</td>
<td></td>
<td></td>
<td></td>
<td>0</td>
</tr>
<tr>
<td>Wearing Course 2</td>
<td></td>
<td></td>
<td></td>
<td>0</td>
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<tr>
<td>Wearing Course 3</td>
<td></td>
<td></td>
<td></td>
<td>0</td>
</tr>
<tr>
<td>Subbase 1</td>
<td></td>
<td></td>
<td></td>
<td>0</td>
</tr>
<tr>
<td>Subbase 2</td>
<td></td>
<td></td>
<td></td>
<td>0</td>
</tr>
<tr>
<td>Subbase 3</td>
<td></td>
<td></td>
<td></td>
<td>0</td>
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<tr>
<td>Subbase 4</td>
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</tr>
<tr>
<td>Total</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

Enforcement and Shoulder Volume [cubic ft]

Period of Analysis [yr] (10 yr or less) 40

Consortium on Green Design and Manufacturing
University of California, Berkeley

PaLATE
Pavement Life-cycle Assessment Tool for Environmental and Economic Effects
Existing Tools: Plant Diagnostic Tool

Source: Pennsylvania Asphalt Pavement Association
The Promise: Production Impact

Less Energy + Less Impact on Environment

Source: FHWA
Models: Fuel Consumption

Estimate how much energy you can save

- 5% Moisture
- 2% Moisture

Fuel Consumption (gal / ton mix)

Mix Temp (°F)

0.25 Gallon Per 50 F
Opportunities for Asphalts

- **Design for superior safety**
  - Selecting gradation to control texture spectrum
  - Better water drainage results in lower skid risk and better visibility
  - Specific surface texture can increase friction

- **Design for less noise**
  - Dense graded but selected texture spectrum
  - Reduce noise generation
  - Increase noise absorption
Asphalt – Drainable Surface

Safety through better visibility and friction

San Antonio Interstate Highway IH 35 before and after paving with Asphalt Rubber (RPA News, Vol 7, No.4, Spring 2004)
Macro-texture/Laser Profilometer

Work in collaboration (University of Pisa)

<table>
<thead>
<tr>
<th>Device</th>
<th>Sampling Rate</th>
<th>Sampling Interval</th>
<th>Vertical Resolution</th>
<th>Measuring Speed</th>
<th>Length of Profile</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stationary Profilometer</td>
<td>16 kHz</td>
<td>0.1 mm</td>
<td>0.05 mm</td>
<td>Manual</td>
<td>750 mm</td>
</tr>
<tr>
<td>Mobile Profilometer</td>
<td>16 kHz</td>
<td>1 mm</td>
<td>0.05 mm</td>
<td>20 km/h</td>
<td>unlimited</td>
</tr>
</tbody>
</table>
Example of Measurements

Wisconsin – WHRP Project Mixes
Macrotexture Spectrum
To Reduce Tire/Road Noise

• Optimize “Texture level” to generate less noise

(After Losa et al. 2009)
Noise Absorption Modeling

Voids Structure (Losa et al. 2008/09)

\[ \alpha = F(D_P, L_P, D_A, L_A) \]

\[ (D_P, L_P, D_A, L_A) = G(\text{Composition Characteristics}) \]
Noise Absorption Measurements

Absorption Coefficient (Alpha)
Micro-texture (Friction) Measurements

- British Pendulum Skid Resistance Tester
- Friction measured by swinging the pendulum.

- The loss of the kinetic energy as result of the interaction between the rubber and the sample surface is reported as the British Pendulum Number (BPN)

- Higher BPN values indicate higher surface microtexture and better skid resistance.
BPN – Friction Number
As a function of Aggregate Gradation

\[ R^2 = 0.7509 \]
Visualization and Imaging
UW- MSU Software 09

Will be proposed as an AASHTO Standard

(1) Image processing

(2) Image analysis
Software Updates of ’09
Detail of two part process

(1) Image processing

(2) Image analysis

Contact points
Orientation
Segregation
Harmonic Fit Parameters

\[ \delta = \text{Predominant angle}, \ A = \text{Severity of angle dispersion} \]
Effect of Compaction Method – Initial Analysis

<table>
<thead>
<tr>
<th>Compaction Method</th>
<th>δ</th>
<th>A</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kneading Compactor</td>
<td>126</td>
<td>2.78</td>
</tr>
<tr>
<td>Marshall</td>
<td>125</td>
<td>2.76</td>
</tr>
<tr>
<td>German Steel Sector</td>
<td>167</td>
<td>0.22</td>
</tr>
<tr>
<td>Superpave Gyratory</td>
<td>90</td>
<td>5.54</td>
</tr>
</tbody>
</table>

δ: Indicates the predominant orientation angle
A: represents the amplitude or severity of deviation from uniform (zero=uniform)
FHWA-UW -- X-Ray CT Imaging
Hot Mix Asphalt

LCPC Mix compacted to 35 gyrations (~4% air voids)

LCPC Mix compacted to 160 gyrations (~1.5% air voids)

Images from Kutay et al. 2008
Future Highways in The USA – Will be built with Less Impact on Environment
Low Energy, Low Emissions, and Low Noise
Asphalt, can deliver these in the NEAR future

- ~ 4.0 Million Miles
- ~ 2.2 million Paved
- ~ 93% Asphalt
- ~ 30 million tons/Y

- ~ 4-5 million Modified Asphalts
Future Highways in The USA – Will be built with Less Impact on Environment Low Energy, Low Emissions, and Low Noise Asphalt, can deliver these in the NEAR future
Concluding Remarks

• The next 10 years, many opportunities

• Asphalt will not be the same, it will much improved and more function specific
  – Opportunities for better role in pavement structure through MEPDG
  – Opportunities for lower cost and less impact on environment
  – Less energy, less emissions, and less noise
  – We will see more modified binders and mixtures
Thank You for this Opportunity

Questions!