Implementation of M-E PDG in Kansas

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Projects related to the M-E Guide Implementation and Calibration

- Kansas HMA Fatigue and Stiffness Study
- Pool Fund Study with KDOT and NYSDOT
- APT Pooled Fund Experiment for Flexible Pavement Response Verification
KS HMA Fatigue and Stiffness Study
K-TRAN Project 02-06

- 2002-2004
- Four HMA base mixes tested for:
  - Dynamic modulus (5 temperature, 5 frequencies and 4 replicates)
  - Third-point beam fatigue (4 strain levels, 4 temperatures, 4 replicates)
- Final report submitted and published
# KS HMA Characteristics

<table>
<thead>
<tr>
<th></th>
<th>Mix A</th>
<th>Mix B</th>
<th>Mix C*</th>
<th>Mix D</th>
</tr>
</thead>
<tbody>
<tr>
<td>Binder Grade</td>
<td>PG64-22</td>
<td>PG64-22</td>
<td>PG70-28*</td>
<td>PG70-28</td>
</tr>
<tr>
<td>Asphalt Content (%)</td>
<td>5.20</td>
<td>6.25</td>
<td>6.25</td>
<td>6.25</td>
</tr>
</tbody>
</table>

* contains SBS polymer

B & C had the same aggregate structure
Fatigue life – Mix B

![Graph showing fatigue life for different strains and temperatures]

- Vertical axis: $N_f$ (number of cycles to failure)
- Horizontal axis: Strain (microstrain)
- Colors represent different temperatures:
  - Yellow: 4 C
  - Red: 10 C
  - Blue: 20 C
  - Green: 30 C

Values:
- At 125 microstrains:
  - 4 C: $1.0 \times 10^7$
  - 10 C: $1.0 \times 10^6$
  - 20 C: $1.0 \times 10^6$
  - 30 C: $1.0 \times 10^5$

- At 250 microstrains:
  - 4 C: $1.0 \times 10^7$
  - 10 C: $1.0 \times 10^6$
  - 20 C: $1.0 \times 10^6$
  - 30 C: $1.0 \times 10^5$

- At 375 microstrains:
  - 4 C: $1.0 \times 10^6$
  - 10 C: $1.0 \times 10^5$
  - 20 C: $1.0 \times 10^5$
  - 30 C: $1.0 \times 10^4$

- At 500 microstrains:
  - 4 C: $1.0 \times 10^5$
  - 10 C: $1.0 \times 10^4$
  - 20 C: $1.0 \times 10^4$
  - 30 C: $1.0 \times 10^3$
Measured vs. Predicted Fatigue Life

The graph shows the relationship between strain (microstrain) and fatigue life ($N_f$) for different categories labeled as A-NCHRP, A, B-NCHRP, B, C-NCHRP, C, D-NCHRP, and D.
Dynamic Modulus vs. Stiffness @ 10 Hz

- Mix A
- Mix B
- Mix C
- Mix D

Flexural Stiffness (MPa) vs. Dynamic Modulus (MPa)

- 2:1
- 3:1
Two states are participating: NY and KS
• Work for Kansas is done; Final report reviewed
• Work for New York:
  • On-going
  • Modified work plan
Major Tasks in the NYSDOT Work Plan

1. Collect and Review Literature
2. Establish Pavement Performance and Material Database
3. Analytical Model Calibration – **DELETED**
4. Traffic Data Processing
5. Reporting and Training
Witczak Equation

\[
\log|E^*| = -1.249937 + 0.029232 \, P_{200} - 0.001767 \, (P_{200})^2 + \\
+ 0.002841 \, P_4 - 0.058097 \, V_a - 0.802208 \, \frac{V_{beff}}{(V_{beff} + V_a)} + \\
+ \left[ 3.871977 - 0.0021 \, P_4 + 0.003958 \, P_{38} - 0.000017 \, (P_{38})^2 + 0.00547 \, P_{34} \right] \\
\frac{1}{1 + e^{(-0.603313 - 0.313351 \log f - 0.393532 \log \eta)}} 
\]

\(E^*\) = Asphalt Mix Dynamic Modulus, in 10^5 psi
\(\eta\) = Bitumen viscosity in 10^6 poise
\(f\) = Load frequency in Hz
\(V_a\) = % air voids in the mix, by volume
\(V_{beff}\) = % effective bitumen content, by volume
\(P_{34}\) = % retained on the ¾ inch sieve,
\(P_{38}\) = % retained on the 3/8 inch sieve,
\(P_4\) = % retained on the # 4 sieve,
\(P_{200}\) = % passing the # 200 sieve
Measured vs. Predicted Dynamic Modulus
NY Region 5 Mix 1

Measured Modulus (MPa) vs. Predicted Modulus (MPa)

Data points for different temperatures:
- 4°C (red diamonds)
- 10°C (open circles)
- 20°C (green triangles)
- 30°C (blue crosses)
- 35°C (cyan dots)

The graph shows a linear relationship between measured and predicted moduli with a line of best fit indicating a 1:1 ratio.
Dynamic Modulus vs. Temperature
KS Mix 9a (VTM=4%) – 10Hz

![Graph showing dynamic modulus vs. temperature for KS Mix 9a (VTM=4%) at 10Hz. The graph includes predictions from DSR, NCHRP, and Hirsch methods, as well as measured data.](image-url)
DSR Predicted vs. Measured Dynamic Modulus - KS Mix 9a
NCHRP Predicted vs. Measured
KS Mix 9b (VTM = 7%)
Findings

• The ratio between measured and predicted moduli was close to 2 in most cases for Kansas mixes and between 0.8 and 1.2 for New York mixes

• The mix C (polymerized) had a longer fatigue life than mix B with unmodified binder

• Higher dynamic modulus at low temperatures and at higher frequencies for all mixes tested

• For Kansas mixes, the Witczak and Hirsch models gave better predictions for mixes with 7% air voids than for mixes with 4% air voids

• The moduli predicted by the Hirsch model were the lowest for most cases
KDOT PCCP Sensitivity Analysis and Comparison

• Eight in-service PCC projects (includes 3 LTPP SPS-2 sections)
• All material inputs were derived from actual construction test results
• Initial analysis was done for AASHTO MEPDG default traffic data
• Kansas traffic inputs and axle load spectra were derived from KDOT AVC and WIM data analysis
KDOT PCCP Sensitivity Analysis and Comparison (Contd..)

- COTE tests were done at FHWA Turner-Fairbanks Research Center
- Performance prediction results (for IRI and faulting) were compared with Kansas PMS or LTPP data
- Sensitivity analysis was conducted for each project
## KS PCCP Comparison

<table>
<thead>
<tr>
<th>Project</th>
<th>Route</th>
<th>County</th>
<th>Year Built</th>
<th>Slab Thickness (in)</th>
<th>AADT</th>
<th>% Trucks</th>
<th>Initial IRI (in/mile)</th>
<th>IRI @ 2003 (in/mile)</th>
</tr>
</thead>
<tbody>
<tr>
<td>K-2611-01</td>
<td>I-70</td>
<td>Geary</td>
<td>1990</td>
<td>11</td>
<td>9,000</td>
<td>18</td>
<td>60</td>
<td>68</td>
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<tr>
<td>K-3344-01</td>
<td>I-70</td>
<td>Shawnee</td>
<td>1993</td>
<td>10.5</td>
<td>55,000</td>
<td>5</td>
<td>96</td>
<td>106</td>
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<tr>
<td>SPS-2 (S5)*</td>
<td>I-70</td>
<td>Dickinson</td>
<td>1992</td>
<td>11</td>
<td>11,970</td>
<td>22.3</td>
<td>122</td>
<td>130</td>
</tr>
<tr>
<td>SPS-2 (S6)**</td>
<td>I-70</td>
<td>Dickinson</td>
<td>1992</td>
<td>11</td>
<td>11,970</td>
<td>22.3</td>
<td>98</td>
<td>102</td>
</tr>
<tr>
<td>SPS-2 (Control)</td>
<td>I-70</td>
<td>Dickinson</td>
<td>1992</td>
<td>12</td>
<td>11,970</td>
<td>22.3</td>
<td>95</td>
<td>103</td>
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<tr>
<td>K-3216-02</td>
<td>US-50</td>
<td>Chase</td>
<td>1997</td>
<td>10</td>
<td>2,670</td>
<td>45.5</td>
<td>59</td>
<td>63</td>
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<tr>
<td>K-3217-02</td>
<td>US-50</td>
<td>Chase</td>
<td>1997</td>
<td>10</td>
<td>2,505</td>
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<td>72</td>
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<tr>
<td>K-3382-01</td>
<td>K-7</td>
<td>Johnson</td>
<td>1995</td>
<td>9</td>
<td>9,666</td>
<td>7</td>
<td>81</td>
<td>86</td>
</tr>
</tbody>
</table>

* 4” Portland Cement -Treated Base and 6” Lime-Treated Subgrade
** 6” Lean Concrete Base and Fly Ash Subgrade
Findings

• IRI is the most sensitive to traffic volume
• With project-specific Kansas traffic input, IRI, Faulting and % Slabs cracked values are lower than those with default MEPDG traffic inputs
• Percent slabs cracked increases significantly with increasing truck traffic
• Faulting is the least sensitive output
APT Pooled Fund Study

TPF-5(048) : VERIFICATION OF MECHANISTIC-EMPIRICAL DESIGN MODELS FOR FLEXIBLE PAVEMENTS THROUGH APT TESTING

• Four states: MO, IA, NE, KS
• Two HMA mixes tested for each state
• Two pavements tested for each mix
• Instrumented pavements
• Experiment with controlled temperature and loading
• Three year experiment
APT Pooled Fund Study
Wheel Load Assembly
Pavement Structures
Fatigue Cracking Experiment @ 10°C (50°F)

- 3.5 in. HMA1
- 3.5 in. HMA2
- 6 in. AB-3 stone
- SUBGRADE

Rutting Experiment @ 40°C (104°F)

- 7 in. HMA1
- 7 in. HMA2
- 6 in. AB-3 stone
- SUBGRADE

SS  South Pit  SN

MS  Middle Pit  MN²⁵
Sensor Location for CISL Experiment #14

**Sensors**
- Thermocouple
- Longitudinal / Transverse Strain Gage
- Stress Cell
- Single Layer Deflectometer
Current Status

- Kansas experiment is complete
- Missouri rutting experiment is also complete
- Missouri fatigue test is currently going on
- Iowa sections will be constructed this Spring
- Project is expected to be complete this year
Acknowledgement

• Dr. Stefan Romanoschi, UT-Arlington
• Kansas Department of Transportation
• TAC for the MSAPT Pooled Fund Study
Thank you!