Performance of Concrete Pavements

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Abilene, KS

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Overview

- Long Term Pavement Performance Program
- National SPS-2 Performance
- National SPS-2 PavementME Predictions
- Kansas SPS-2 PavementME Predictions
LTPP’s GOAL is…

to provide answers to **HOW** and **WHY**
pavements perform as they do!
LTPP’s CORE FUNCTIONS

- Data Collection and Management
- Data Analysis
- Product Development
Test Sections
National SPS-2 Performance Roughness

- The initial IRI of SPS-2 sections after placement ranged from 48 to 139 in/mi with a mean of 82 in/mi.

- JPCP constructed on PATB were smoother than sections constructed on LCB or untreated aggregate base.
National SPS-2 Performance Roughness
National SPS-2 Performance Faulting

- Widened slab sections show less faulting than conventional width slabs.
- Sections with aggregate base show the highest joint faulting level. Sections with LCB and PATB have the lowest joint faulting.
National SPS-2 Performance Transverse Cracking

- Thinner (203 mm) slabs show more transverse cracks than thicker slabs. Sections with a thinner slab and a widened slab show the highest level of transverse cracking.

- Sections with PATB show the lowest percentage of slabs cracked transversely, while the sections with an LCB show the highest transverse cracking.
National SPS-2 Performance Longitudinal Cracking

- Sections with PATB show the lowest total longitudinal cracking levels, while the sections with LCB show the highest longitudinal cracking.
National SPS-2 Performance Lessons Learned (so far)

- In general, LCB provided the worst performance and PATB over DGAB provided the best performance.
- Longitudinal cracking was influenced by base type and slab thickness.
- Widened lanes contributed to lower transverse joint faulting.
National SPS-2 PavementME Predictions

Slabs Cracked Transversely

<table>
<thead>
<tr>
<th>Predicted Slabs Cracked</th>
<th>Measured Slabs Cracked</th>
</tr>
</thead>
<tbody>
<tr>
<td>LOW</td>
<td>I</td>
</tr>
<tr>
<td>HIGH</td>
<td>II</td>
</tr>
<tr>
<td></td>
<td>III</td>
</tr>
<tr>
<td></td>
<td>IV</td>
</tr>
</tbody>
</table>

LONG TERM PERFORMANCE

KANSAS Department of Transportation
National SPS-2 PavementME Predictions

- **Type I sections**
  - Lower traffic loads
  - Thicker PCC
  - 34% with PATB and 24% with LCB

- **Type II sections**
  - 28% with PATB and 47% with LCB
  - PCC with higher strength and/or less elastic

- **Type III sections**
  - Heavier traffic loads
  - PCC with lower strength and/or more elastic
  - No LCB sections

- **Type IV sections**
  - Most design factors are near the average
# National SPS-2 PavementME Predictions

<table>
<thead>
<tr>
<th>State</th>
<th>Type I</th>
<th>Type II</th>
<th>Type III</th>
<th>Type IV</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arizona</td>
<td>10</td>
<td>5</td>
<td>4</td>
<td>-</td>
</tr>
<tr>
<td>Arkansas</td>
<td>5</td>
<td>2</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>California</td>
<td>3</td>
<td>5</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>Colorado</td>
<td>9</td>
<td>4</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Delaware</td>
<td>13</td>
<td>1</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Iowa</td>
<td>12</td>
<td>1</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Kansas</td>
<td>9</td>
<td>2</td>
<td>1</td>
<td>1</td>
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<tr>
<td>Michigan</td>
<td>7</td>
<td>6</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Nevada</td>
<td>2</td>
<td>10</td>
<td>-</td>
<td>-</td>
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<tr>
<td>North Carolina</td>
<td>12</td>
<td>2</td>
<td>-</td>
<td>-</td>
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<tr>
<td>North Dakota</td>
<td>16</td>
<td>2</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Ohio</td>
<td>5</td>
<td>13</td>
<td>-</td>
<td>1</td>
</tr>
<tr>
<td>Washington</td>
<td>9</td>
<td>4</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Wisconsin</td>
<td>20</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>
National SPS-2 – Slabs Cracked Transverse vs. Total

<table>
<thead>
<tr>
<th>Slabs Cracked Transverse</th>
<th>Slabs Cracked - Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0</td>
</tr>
<tr>
<td>0</td>
<td>112</td>
</tr>
<tr>
<td>0-20</td>
<td>0</td>
</tr>
<tr>
<td>20-40</td>
<td>0</td>
</tr>
<tr>
<td>40-60</td>
<td>0</td>
</tr>
<tr>
<td>60-80</td>
<td>0</td>
</tr>
<tr>
<td>80-100</td>
<td>0</td>
</tr>
</tbody>
</table>
Predictions using agency calibration coefficients did not significantly improve upon predictions using default calibration values.

However, the Root Mean Square Error (RMSE) of Type III predictions reduced by 13.6 (% of slab cracked) on average.

\[
RMSE = \left[ \frac{1}{N} \sum_{i=1}^{N} (x_m - x_p)^2 \right]^{1/2}
\]

Where:
\(x_m\) = measured performance
\(x_p\) = predicted performance
\(N\) = sample size
National SPS-2
RMSE Distribution – Faulting

- Default Calibration
- Agency Calibration

<table>
<thead>
<tr>
<th>RMSE Bins (inch)</th>
<th>Number of Test Sections</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-0.015 (GOOD)</td>
<td>60</td>
</tr>
<tr>
<td>0.015-0.03 (FAIR)</td>
<td>20</td>
</tr>
<tr>
<td>0.03-0.06 (POOR)</td>
<td>10</td>
</tr>
<tr>
<td>0.06-0.19 (VERY POOR)</td>
<td>5</td>
</tr>
</tbody>
</table>
Kansas SPS-2
Measured Roughness

Survey Date

IRI (in/mi)
Kansas SPS-2
Predicted Roughness
Kansas SPS-2
Measured Faulting

Survey Date
Jan-93 Jan-95 Jan-97 Jan-99 Jan-01 Jan-03 Jan-05 Jan-07 Jan-09 Jan-11 Jan-13 Jan-15 Jan-17 Jan-19
Faulting (in)
-0.04 -0.01 0.00 0.01 0.02 0.03 0.04 0.05 0.06 0.07 0.08 0.09 0.10 0.11 0.12 0.13 0.14 0.15 0.16 0.17 0.18 0.19 0.20 0.21

Other Sites
0206
Kansas SPS-2 Predicted Faulting

Faulting (in)

Date

Jan-93 Jan-95 Jan-97 Jan-99 Jan-01 Jan-03 Jan-05 Jan-07 Jan-09 Jan-11 Jan-13 Jan-15 Jan-17 Jan-19

-0.04 0.01 0.06 0.11 0.16 0.21

0202, 0201
0210
0204
0203, 0209
Other Sites
Kansas SPS-2
Measured Cracked Slabs
Kansas SPS-2
Predicted Cracked Slabs
Kansas SPS-2
Good Prediction

No Similar Sites
Kansas SPS-2 Over-Prediction

No Similar Sites
Kansas SPS-2
No Significant Distress

Similar Sites:
0204, 0205, 0206, 0207, 0210, 0211, 0212, and 0259
Kansas SPS-2 Under-Prediction

![Graph showing cracked slabs over time with measured and predicted data.]

Similar Site: 0208

**Cracked Slabs - Transverse (%)**

- Measured
- Predicted with Default Calibrations
0201 was performing as predicted until slab replacements were performed. Ultimately, 0201 performed better than predicted and had a high RMSE value.
Kansas SPS-2 PavementME Findings

- 0209 performed better than predicted.
- 0210 is similar to 0209 except that 0210 used high strength PCC, but the two sections appear to have performed the same.
Kansas SPS-2 PavementME Findings

- 0202 and 0208 performed worse than predicted.
- However, the transverse cracks surveyed in 0208 may be due to surveyor variability.
Kansas SPS-2 PavementME Findings

- 0201 and 0202 performed poorest in comparison to the other sections.
- Both section were thin (8”) PCC on a granular base.
- FWD backcalculation also suggests that the subgrade is a little weaker on these two sections.
SPS-2 Future

- LTPP monitoring
- SPS-2 Pavement Preservation Pooled Fund Study