Performance of Concrete Pavements

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Denver, CO

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Overview

• Construction Effects on PCC Performance
• Long Term Pavement Performance Program
• National SPS-2 Performance
• National SPS-2 PavementME Predictions
• Colorado SPS-2 PavementME Predictions
## Construction Effects on PCC Performance

<table>
<thead>
<tr>
<th>Construction Practice</th>
<th>Classification</th>
<th>Effect on Distress Type</th>
<th>Average Ranking</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>JPCP Faulting</td>
<td>JPCP Cracking</td>
</tr>
<tr>
<td>Dowel Placement</td>
<td>Others</td>
<td>3</td>
<td>X</td>
</tr>
<tr>
<td></td>
<td>Mechanical Install</td>
<td>2</td>
<td>X</td>
</tr>
<tr>
<td></td>
<td>Preplaced In Baskets</td>
<td>1</td>
<td>X</td>
</tr>
<tr>
<td>Joint Forming</td>
<td>Sawed</td>
<td>2</td>
<td>X</td>
</tr>
<tr>
<td></td>
<td>Plastic Insert</td>
<td>1</td>
<td>X</td>
</tr>
<tr>
<td>Coarse Agg. Content</td>
<td>&lt;1800 Kg/M³</td>
<td>X</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>&gt;1800 Kg/M³</td>
<td>X</td>
<td>1</td>
</tr>
<tr>
<td>Fine Agg. Content</td>
<td>&lt;1300 Kg/M³</td>
<td>X</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>&gt;1300 Kg/M³</td>
<td>X</td>
<td>2</td>
</tr>
<tr>
<td>Concrete Curing</td>
<td>Membrane</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td></td>
<td>Polythene</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td></td>
<td>Burlap</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Concrete Texture</td>
<td>Astroturf</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td></td>
<td>Others</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td></td>
<td>Broom</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td></td>
<td>Tine</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td></td>
<td>Burlap Drag</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td></td>
<td>Grooved Float</td>
<td>X</td>
<td>X</td>
</tr>
</tbody>
</table>

Note: X denotes no effect; ranking of 1-5 indicates best-worst performance
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
LTPP Data & Information

Climate → Materials → Structure → Load → Distress

Response
Test Sections

LTPP GPS and SPS Pavement Sites
SPS-2
Traffic and Climate

Map of the United States showing traffic and climate data with the following values:
- 420 KEASL/YR
- 730 KEASL/YR
- 1,870 KEASL/YR
- 390 KEASL/YR
- 250 KEASL/YR
- 3,560 KEASL/YR
- 570 KEASL/YR
- 630 KEASL/YR
- 760 KEASL/YR
- 720 KEASL/YR
- 730 KEASL/YR
- 570 KEASL/YR

Legend:
- Dry
- Non-freeze
- Wet
- Freeze

Long Term Pavement Performance

LTTP
CDOT
CO
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

Average Change in IRI per Year (in/mi/yr)

Number of Test Sections

< 0 0-2 2-4 4-8 8-16 > 16
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>LOW I</td>
</tr>
<tr>
<td>HIGH</td>
<td>HIGH II</td>
</tr>
<tr>
<td></td>
<td>LOW III</td>
</tr>
<tr>
<td></td>
<td>HIGH IV</td>
</tr>
</tbody>
</table>
National SPS-2 PavementME Predictions

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

- **Type 2 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>
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<tr>
<td>Delaware</td>
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<tr>
<td>Iowa</td>
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<td>Kansas</td>
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<tr>
<td>Michigan</td>
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<td>6</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Nevada</td>
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<td>10</td>
<td>-</td>
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<tr>
<td>North Carolina</td>
<td>12</td>
<td>2</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>North Dakota</td>
<td>16</td>
<td>2</td>
<td>-</td>
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<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>
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</tr>
<tr>
<td>Wisconsin</td>
<td>20</td>
<td>-</td>
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</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>
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<tr>
<td>20-40</td>
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<tr>
<td>40-60</td>
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<tr>
<td>60-80</td>
<td>0</td>
</tr>
<tr>
<td>80-100</td>
<td>0</td>
</tr>
</tbody>
</table>
National SPS-2 PavementME Findings

- 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.

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

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

Number of Test Sections

RMSE Bins (inch)

0-0.015 (GOOD)
0.015-0.03 (FAIR)
0.03-0.06 (POOR)
0.06-0.19 (VERY POOR)

Default Calibration
Agency Calibration
Colorado SPS-2
Measured Roughness
Colorado SPS-2
Predicted Roughness
Colorado SPS-2
Predicted Faulting

![Graph showing predicted faulting over time for different dates, with specific dates like Jan-93 to Jan-19 marked on the x-axis and faulting in inches on the y-axis. The graph includes markers for different years and combines markers for specific dates like 0214, 0216, & 0218, 0213, 0222, & 0259, 0221, 0224, & 0215, 0217, 0219, 0220, & 0223.]
Colorado SPS-2 Measured Cracked Slabs
Colorado SPS-2
Predicted Cracked Slabs
Colorado SPS-2 Over-Prediction

• All PavementME predictions showed no distress.
• Therefore, none of the Colorado SPS-2 test sections performed better than the PavementME prediction for cracking.
Example (Arizona) Over-Prediction
Colorado SPS-2
No Significant Distress

Similar Sites:
0214, 0215, 0219,
0220, 0221, 0222,
0224, and 0259
Colorado SPS-2
Under-Prediction

Similar Sites:
0217, 0218, and 0223

0216

Cracked Slabs - Transverse (%)

Measured
Predicted with Default Calibrations
Predicted with Local Calibrations

Year
01/01/93 01/01/98 01/01/03 01/01/08 01/01/13 01/01/18
Colorado SPS-2 PavementME Findings

- 2 of 4 sections (0217 & 0218) that performed worse than predicted had:
  - 8” PCC thickness
  - CTB base type
  - High severity cracking
Colorado SPS-2 PavementME Findings

• The other two sections:
  ■ 0216 had 11.9” high-strength PCC and DGAB
  ■ 0223 had 11.7” low-strength PCC and PATB
SPS-2 Blowup

- Transition between 080215 and 080218 in June 2015
SPS-8 Comparison Sections

- Absence of heavy loading
SPS-2
Future

- LTPP monitoring
- SPS-2 Pavement Preservation Pooled Fund Study
For more information:
https://www.fhwa.dot.gov/research/tfhrc/programs/infrastructure/pavements/ltpp/getdata.cfm
ksenn@ncenet.com

More products and information at:
https://infopave.com

Thank You