Performance of Concrete Pavements

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Des Moines, IA

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Overview

- Construction Effects on PCC Performance
- Long Term Pavement Performance Program
- National SPS-2 Performance
- National SPS-2 PavementME Predictions
- Iowa 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
- Load
- Structure
- Distress
- Materials
- Response

LONG TERM PERFORMANCE

LTPP

Pavement
Test Sections

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

Non-freeze
Freeze
Dry
Wet
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

![Bar chart showing average change in IRI per year in inches per mile per year (in/mi/yr) for different categories of test sections ranging from < 0 to > 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>LOW</td>
<td>LOW III</td>
</tr>
<tr>
<td>HIGH</td>
<td>HIGH IV</td>
</tr>
</tbody>
</table>
## National SPS-2 PavementME Predictions

<table>
<thead>
<tr>
<th>Type I sections</th>
<th>Type III sections</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lower traffic loads</td>
<td>Heavier traffic loads</td>
</tr>
<tr>
<td>Thicker PCC</td>
<td>PCC with lower strength and/or more elastic</td>
</tr>
<tr>
<td>34% with PATB and 24% with LCB</td>
<td>No LCB sections</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Type 2 sections</th>
<th>Type IV sections</th>
</tr>
</thead>
<tbody>
<tr>
<td>28% with PATB and 47% with LCB</td>
<td>Most design factors are near the average</td>
</tr>
<tr>
<td>PCC with higher strength and/or less elastic</td>
<td></td>
</tr>
</tbody>
</table>
# National SPS-2 PavementME Predictions

<table>
<thead>
<tr>
<th>State</th>
<th>Number of Test Sections</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Type I</td>
</tr>
<tr>
<td>Arizona</td>
<td>10</td>
</tr>
<tr>
<td>Arkansas</td>
<td>5</td>
</tr>
<tr>
<td>California</td>
<td>3</td>
</tr>
<tr>
<td>Colorado</td>
<td>9</td>
</tr>
<tr>
<td>Delaware</td>
<td>13</td>
</tr>
<tr>
<td>Iowa</td>
<td>12</td>
</tr>
<tr>
<td>Kansas</td>
<td>9</td>
</tr>
<tr>
<td>Michigan</td>
<td>7</td>
</tr>
<tr>
<td>Nevada</td>
<td>2</td>
</tr>
<tr>
<td>North Carolina</td>
<td>12</td>
</tr>
<tr>
<td>North Dakota</td>
<td>16</td>
</tr>
<tr>
<td>Ohio</td>
<td>5</td>
</tr>
<tr>
<td>Iowa</td>
<td>9</td>
</tr>
<tr>
<td>Wisconsin</td>
<td>20</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>
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.

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

Where:
- $x_m = measured\ performance$
- $x_p = predicted\ performance$
- $N = sample\ size$
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
Iowa SPS-2
Measured Roughness

![Graph showing Measured Roughness over time for Iowa SPS-2 with survey dates from Jan-93 to Jan-19.](image-url)
Iowa SPS-2
Predicted Roughness

Graph showing predicted roughness IRI (in/mi) vs. date from Jan-93 to Jan-19 for various sites including 0215, 0219, 0220, 0222, 0223, and Other Sites.
Iowa SPS-2
Measured Faulting

Faulting (in)

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
Iowa SPS-2
Predicted Faulting

Faulting (in)

Date

-0.04
-0.01
0.01
0.06
0.11
0.16
0.21

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

0213, 0217
0214, 0219, 0220
0215
0216, 0222
0223
0218, 0221
0214, 0219, 0220
023
0213, 0217
Iowa SPS-2
Measured Cracked Slabs

Slabs with Transverse Cracking (%)

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

0214 0218

Other Sites
Iowa SPS-2
Predicted Cracked Slabs

Slabs with Transverse Cracking (%)

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

Other Sites
0213
Iowa SPS-2 Over-Prediction

- All PavementME predictions showed very little to no distress (less than 2%).
- Therefore, none of the Iowa SPS-2 test sections performed significantly better than the PavementME prediction.
Example (Arizona) Over-Prediction

Arizona 0213

Cracked Slabs - Transverse (%)

Year

Measured
Predicted with Default Calibrations
Predicted with Local Calibrations
Iowa SPS-2
No Significant Distress

Similar Sites:
0213, 0214, 0215, 0217, 0219, 0220, 0221, 0222, 0223, 0224, and 0259
Iowa SPS-2 Under-Prediction

No Similar Sites
Iowa SPS-2 PavementME Findings

- 0218 performed worse than predicted; having 11.8% of slabs cracked by 2016.
- 0217 also performed worse than predicted, but the percent of slabs cracked is 0% due to slab replacements that occurred in 2006.
Both 0217 and 0218 had:
- 8” PCC thickness
- CTB base type
Iowa SPS-2
PavementME Findings

- 0214, 0216, 0220, and 0221 started showing a small amount of distress by 2015 (3% to 6% of slabs cracked).
  - Three of these sections had 8” PCC
  - Two had DGAB and two had ATB base type
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