EVALUATION OF IN-SITU VARIABILITY OF CONCRETE PAVEMENT THICKNESS AND REVISED MEASUREMENT FREQUENCY PROTOCOL

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Jointed plain concrete pavement (JPCP) design parameters

Steve Muench, Pavement Interactive, 2003
JPCP

Key JPCP distresses
• Transverse cracking
• Joint faulting

Concrete layer thickness and flexural strength most important parameters for influencing transverse cracking
Problem Statement

Lack of information on variability of concrete layer thickness
Approach

• Evaluate concrete layer thickness in JPCPs using core and NDT data
• Propose methods for recommending thickness measurement sample spacing
Thick ness Evaluation Location

• JPCP concrete layer thickness evaluated at 3 locations in southern MN.
• Described as Hwy 1, Hwy 2, and Hwy 3.

<table>
<thead>
<tr>
<th>JPCP ID</th>
<th>Concrete Layer Design Thickness (in.)</th>
<th>Number of Lanes</th>
<th>Pavement Classification (MN)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hwy 1</td>
<td>9</td>
<td>4</td>
<td>Minnesota State Highway</td>
</tr>
<tr>
<td>Hwy 2</td>
<td>8</td>
<td>4</td>
<td>Minnesota State Highway</td>
</tr>
<tr>
<td>Hwy 3</td>
<td>8</td>
<td>2</td>
<td>County State Aid Highway (CSAH)</td>
</tr>
</tbody>
</table>
Concrete Cores
Ultrasonic Tomography
Sample Spacing and Length

Each JPCP was evaluated according to three different sampling protocols:

**NDT**
- 15 ft. Spacing
- +1000 ft.
- Time: 1 hr/mile

**NDT**
- 2 ft. Spacing
- 500 ft.
- Time: 2 hr/500 ft.

**Cores**
- 1000 ft. Spacing
- +1000 ft.
- Time: 15 min/core
Concrete Layer Thickness Evaluation

- NDT and Cores

<table>
<thead>
<tr>
<th>Hwy 1</th>
<th>Long Length Scale</th>
<th>Short Length Scale</th>
<th>Cores</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Edge</td>
<td>Center</td>
</tr>
<tr>
<td>Length of Pavement Evaluated (ft.)</td>
<td>6645</td>
<td>500</td>
<td>500</td>
</tr>
<tr>
<td>Number of data points</td>
<td>444</td>
<td>204</td>
<td>204</td>
</tr>
<tr>
<td>Design Thickness (in.)</td>
<td>9</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean Thickness (in.)</td>
<td>9.15</td>
<td>8.12</td>
<td>9.02</td>
</tr>
<tr>
<td>Thickness Standard Deviation (in.)</td>
<td>0.45</td>
<td>0.31</td>
<td>0.21</td>
</tr>
<tr>
<td>Max Recorded Thickness (in.)</td>
<td>11.00</td>
<td>9.38</td>
<td>9.45</td>
</tr>
<tr>
<td>Min Recorded Thickness (in.)</td>
<td>8.01</td>
<td>8.01</td>
<td>8.44</td>
</tr>
<tr>
<td>Thickness Range (in.)</td>
<td>3.00</td>
<td>1.38</td>
<td>1.01</td>
</tr>
</tbody>
</table>

- Measurements near edge and center of slab
Summary

• Significant longitudinal thickness variation in JPCPs
• Transverse location is important for performance prediction
• Since core measurements are undesirable in critical locations, NDT is an attractive alternative
How Many Measurements are Necessary?

Model that estimates probability of missing a thickness deficiency for a given sample spacing
Model for Recommending Sample Spacing

Model determines the probability of measuring a concrete thickness below some thickness threshold between sampling points.

\[
\Pr \left( \min_{x} \left[ T(x) \right] < \tau \mid T(0) > \tau \text{ and } T(s) > \tau \right)
\]
Probability of Missing a Thickness Deficiency

![Graph showing probability of missing a thickness deficiency against sample spacing.](image)
Summary

Model

• Predicts probability of missing a thickness deficiency between sample points separated by a distance, S.
• 1000 ft. sample spacing is too far in all cases
Acknowledgements

Professor Lev Khazanovich, Adviser
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MN/DOT
Kyle Hoegh, Rita Lederle, Derek Tompkins
Table 2301-14
Deductions for Thickness Deficiencies

<table>
<thead>
<tr>
<th>Thickness Deficiency Exceeding Permissible Deviations, in [mm]</th>
<th>Adjusted contract unit price per sq. yd [sq. m] of Payment</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.00 – ≤ 0.10 [≤ 3]</td>
<td>None (tolerance)</td>
</tr>
<tr>
<td>0.10 – ≤ 0.20 [3 ≤ ≤ 5]</td>
<td>$0.20 [$0.25]</td>
</tr>
<tr>
<td>0.20 – ≤ 0.30 [5 ≤ ≤ 8]</td>
<td>$0.40 [$0.50]</td>
</tr>
<tr>
<td>0.30 – ≤ 0.40 [8 ≤ ≤ 10]</td>
<td>$0.70 [$0.90]</td>
</tr>
<tr>
<td>0.40 – ≤ 0.50 [10 ≤ ≤ 13]</td>
<td>$1.00 [$1.25]</td>
</tr>
<tr>
<td>0.50 – ≤ 1.00 [13 ≤ ≤ 25]*</td>
<td>$20.00 [$25.00]</td>
</tr>
</tbody>
</table>

* Perform exploratory coring as required by the Engineer.