PERFORMANCE OF IOWA’S CONCRETE OVERLAYS

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Iowa Concrete Paving Association
ACKNOWLEDGMENTS

- Iowa Highway Research Board Project TR-689
- Iowa State University: Yu-An Chen, Dr. Halil Ceylan, Inya Nnelanya, Dr. Omar Smadi
- Natl. CP Tech Center: Dale Harrington, Jerod Gross, Dr. Peter Taylor
- Full report to be published through Iowa Highway Research Board/Iowa DOT this Spring/Summer
OUTLINE

- Concrete Overlays in Iowa
- Project Background & Objectives
- Data Compilation & Collection
- Results and Analysis
- Field Reviews
Concrete overlays: increasing use and acceptance nationwide over past few decades

+ CP Tech Center Guide:
**CONCRETE OVERLAYS IN IOWA**

- Iowa: over 2,000 centerline miles of concrete overlays have been constructed since the late ‘70s
  - Over half constructed since 2005
  - Mostly on rural county highway system
CONCRETE OVERLAYS IN IOWA

- National perspective

+ ACPA overlay project explorer:
How well have Iowa’s overlays performed?

+ Approximately 470/506 overlay projects are still in service today
+ Includes 68/96 constructed before 1990
However, as of 2015, there had been no attempt to characterize performance of overlays to determine expected service life & what made projects successful.
PROJECT OBJECTIVES

- Define performance of Iowa’s concrete overlays
  - Create performance curves
  - Analyze specific design choices and characteristics and link to performance
    - Thickness
    - Joint spacing
    - Traffic
    - Overlay type (thin bonded, unbonded)
- Incorporate lessons learned to improve overlay design and performance
DATA COMPILATION & COLLECTION

- Automated pavement condition data: Iowa Pavement Management Program (IPMP)
  + Opt-in program for local agencies
  + Data collection began in 1996
  + All streets & roads every other year since 2013

- This data then combined with ICPA overlay project info to produce data set
OVERLAY TYPES

- Bonded Concrete Overlay of Concrete (BCOC)
- Bonded Concrete Overlay of Asphalt (BCOA)
  + Defined as thickness ≤ 6 inches
- Unbonded Concrete Overlay of Concrete (UBCOC)
- Unbonded Concrete Overlay of Asphalt (UBCOA)
  + Defined as thickness > 6 inches
DATA DISTRIBUTION

- Typical designs in Iowa
  - Early on: 6 inches on asphalt ("whitetopping") or 6+ inches unbonded on concrete
    - Performance data for projects up to 40 years old
DATA DISTRIBUTION

Typical designs in Iowa

- ‘00s: more types of projects, including thinner overlays
  - Advent of new design procedures, shorter slabs, fibers (some)
  - About 10 years worth of data, with some exceptions

Boone, IA, Constructed 2005
**DATA DISTRIBUTION**

- **Full data set contains all overlay types/designs:**

<table>
<thead>
<tr>
<th>Type of overlay</th>
<th>Total number of projects</th>
<th>Percent of data based on number of projects (%)</th>
<th>Project length (mile)</th>
<th>Percent of data based on length of projects (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bonded concrete on concrete (BCOC)</td>
<td>13</td>
<td>3</td>
<td>67</td>
<td>4</td>
</tr>
<tr>
<td>Unbonded concrete on concrete (UBCOC)</td>
<td>125</td>
<td>32</td>
<td>506</td>
<td>34</td>
</tr>
<tr>
<td>Bonded concrete on asphalt (BCOA)</td>
<td>180</td>
<td>47</td>
<td>671</td>
<td>45</td>
</tr>
<tr>
<td>Unbonded concrete on asphalt (UBCOA)</td>
<td>69</td>
<td>18</td>
<td>255</td>
<td>17</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>387</strong></td>
<td><strong>100</strong></td>
<td><strong>1,499</strong></td>
<td><strong>100</strong></td>
</tr>
</tbody>
</table>
### DATA DISTRIBUTION

#### Distribution based on slab thickness:

<table>
<thead>
<tr>
<th>PCC slab thickness (in.)</th>
<th>Total number of projects</th>
<th>Percent of data based on number of projects (%)</th>
<th>Project length (mile)</th>
<th>Percent of data based on length of projects (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt;3</td>
<td>8</td>
<td>2</td>
<td>20</td>
<td>1</td>
</tr>
<tr>
<td>4</td>
<td>50</td>
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<td>283</td>
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<td>5</td>
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<td>178</td>
<td>12</td>
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<td>6</td>
<td>186</td>
<td>48</td>
<td>621</td>
<td>41</td>
</tr>
<tr>
<td>7</td>
<td>42</td>
<td>11</td>
<td>177</td>
<td>12</td>
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<td>45</td>
<td>3</td>
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<tr>
<td>10</td>
<td>4</td>
<td>2</td>
<td>9</td>
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PERFORMANCE METRICS

- Performance characterized by PCI (Pavement Condition Index) & IRI
- IPMP PCI equation incorporates:
  - IRI (accounts for 40% of PCI)
  - Transverse Cracking
  - Joint Spalling
  - D-cracking

(no faulting)
PERFORMANCE METRICS

- Performance charts:
- PCI scale:
  - Excellent: 81-100
  - Good: 61-80
  - Fair: 41-60
  - Poor: 21-40
  - Very Poor: 0-20

Image: Pavement Interactive
RESULTS AND ANALYSIS

- Data set as a whole:

![Graph showing data distribution and regression line with R² = 0.29. The graph indicates approximately 34 years to PCI = 60. Figures: Chen and Ceylan]
RESULTS AND ANALYSIS

- Data set as a whole:

![Graph showing relationship between Age (year) and IRI (in/mile)]

- $R^2 = 0.24$
- ~40 years to IRI = 170

Figures: Chen and Ceylan
RESULTS AND ANALYSIS

- BCOA only (organized by thickness):

![Graph showing PCC slab thickness vs. Age](Figures: Chen and Ceylan)
RESULTS AND ANALYSIS

- BCOA only (organized by joint spacing):

  PCI appears to increase over time due to changes in IRI measurement around 2011.

  Figures: Chen and Ceylan
RESULTS AND ANALYSIS

- UBCOA only (organized by thickness):

![Graph showing PCC slab thickness (PCI vs. Age) with R² values 0.17 and 0.50 for PCI (PCC slab thickness) 7 in. and 8 in. respectively.](Figures: Chen and Ceylan)
RESULTS AND ANALYSIS

× UBCOC only (organized by thickness):

![Graph showing PCC slab thickness (PCI vs. Age)]

Figures: Chen and Ceylan
RESULTS AND ANALYSIS

- Key findings and trends:
  - Overall performance of Iowa’s concrete overlays has been excellent
    - As a whole: about 34 years to PCI = 60
    - About 40 years to IRI = 170
  - Good performance from each of BCOA, UBCOA & UBCOC
    - Overlays of asphalt slightly better than UBCOC
    - BCOC: less successful overall, but performed well in context of design life expectations
RESULTS AND ANALYSIS

Key findings and trends:

- **Thickness**
  - In general: thicker overlays have performed better for all overlay types (e.g. for BCOA, 6” > 5” > 4”)

- **Transverse joint spacing**
  - Good early performance from short slab designs (6”) on BCOA/thin overlays
  - Older designs with 15-20 foot slabs performed well long-term
  - 12 foot slabs—inconclusive

- **Traffic—inconclusive**
  - Most of these projects are low-volume, <1,000 vpd
  - Not enough truck traffic data available from local agencies
RESULTS AND ANALYSIS

- 12 foot transverse joint spacing
  + Across multiple splits, apparent decline in performance of overlays with 12 foot joint spacing
  + UBCOA (organized by joint spacing):

![Joint spacing (PCI vs. Age)](image)

Figures: Chen and Ceylan
FIELD REVIEWS

- To supplement data analysis, field reviews were performed
  - Verify findings and investigate trends, outliers

Pottawattamie County, IA, Constructed 1993
FIELD REVIEWS

- Observed distresses:
  - Materials-related

Pottawattamie County, IA, Constructed 1999
FIELD REVIEWS

- Observed distresses:
  + Rough ride—construction or **curling/warping**
  + Occasionally faulting

Buchanan County, IA, Constructed 1996
FIELD REVIEWS

- Observed distresses:
  + Load-related, possibly mis- or under-designed

Dallas County, IA, Constructed 2006
FIELD REVIEWS

- Key takeaways:
  - Observed performance generally matches data
  - Poor performing outliers & early failure causes:
    - Materials-related
    - Load-related/under-design
    - Rough ride
  - In short... mostly the same issues that we run into with conventional PCC pavements
    - Be aware of increased potential for curling/warping
    - Beyond above explanations, no direct observations to indicate that there’s a specific problem with 12 ft joint spacing design
CONCLUSIONS

- Overall performance of Iowa’s concrete overlays has been excellent
  - Upwards of 30-40+ year performance life
  - Overlays very well-suited to county highways
  - Good success to date on interstate, state highways, and city streets as well
Thank you!