I-65 South Split Continuously Reinforced Concrete Pavement

Tommy Nantung
INDOT Research and Development Division
Roadmap to Presentation

- Brief history of CRCP in Indiana
- Introduction to CRCP
- Design principle of CRCP in Indiana
- Construction of CRCP in I-65
- Conclusions
History of CRCP

- Introduced in 1921
- The first significant length was constructed by the State of Indiana in 1938.
  - US-40 in Stilesville, 1,200 feet.
What is CRCP?

- Concrete pavement in which longitudinal reinforcing steel is continuous throughout the pavement length.
When and why CRCP?

- Eliminate joint maintenance costs for the life of the pavement,
  - Helping meet the public's desire for reduced work zones and related traveler delays.
- Provide consistent transfer of shear stresses from heavy wheel loads,
  - Consistently quiet ride and less distress development at the cracks.
Advantages of CRCP

- Crack widths are controlled by continuous steel reinforcement
- Joint-related distresses are eliminated with absence of transverse contraction joints
- Provides smooth ride, long service-life
- Has become an optional pavement type for heavy traffic loads, high volume cases, with a low life cycle cost
Design Principle of CRCP

- Design, mix, and construction decisions and practices
  - Should maximize load-transfer efficiency and minimize flexural stresses.

- Cracks that are closely spaced (3-4 ft. maximum is optimum) and tight (0.02 in. at the depth of the reinforcement)
  - Help maximize load-transfer efficiency and minimize flexural stresses,
Closely spaced, tight cracks result when the project includes:

- Adequate longitudinal steel content (0.6 to 0.8 percent of the slab cross-section area).
- Optimum reinforcement diameter.
- Adequate lapping of reinforcement splices.
- Appropriate depth of reinforcement placement.

Thorough consolidation of concrete around the reinforcement,
Design Principle of CRCP

- Large, abrasion-resistant aggregates
  - To promote good aggregate interlock and thus enhance load-transfer efficiency.

- Sufficient slab thickness is required
  - To manage transverse tensile stresses due to truck traffic and curling and warping.

- The foundation must be uniform and stable,
  - To provide good drainage, and extend beyond the slab edge
Design Principle of CRCP

- Longitudinal construction joints must be tied to adjacent pavement at centerline or shoulder.
- Longitudinal contraction joints should be sawed directly over the transverse reinforcement.
Design Alternatives

Texas Two-Steps

Illinois One-Pass

Apples and Oranges
Design Alternatives

Texas Two-Layers

Illinois One Layer
CRCP Behavior - Crack Spacing

- Cracks begin to develop in the transverse direction
- Held tight by longitudinal reinforcing steel
- Cracks spacing 3.5-6ft (Crack width < 0.040 in.)
CRCP Behavior - Crack Spacing

The graph illustrates the relationship between steel stress, crack width, crack spacing, % steel reinforcement, and acceptable design limits for crack spacing. The axes are as follows:

- Y-axis: Steel Stress x 10^3 psi
- X-axis: Crack Spacing (ft)
- Sub-axes: Crack Width x 10^-2 (in.)

Key points:
- Maximum Crack Spacing
- Allowable Steel Stress
- Allowable Crack Width
- Minimum Crack Spacing
- Acceptable Design

The graph helps in determining the appropriate steel stress and crack width for given crack spacing and % steel reinforcement to ensure acceptable design criteria are met.
Crack widths have a crucial effect on CRCP performance

- Infiltration of water
- Incompressibles can enter into wide cracks, excessive bearing stresses at the cracks
- Poor aggregate interlock
- Lead to additional spalling, faulting, secondary cracking, and punchouts
Key Parameters in Design

- Adequate steel reinforcement to maintain tight crack widths
- Sufficient concrete strength and slab thickness to reduce tensile stresses and cracking.
- Selection of hard and angular aggregates with a low CTE that can improve load transfer.
- The use of a stress relieving interlayer beneath the slab, sometimes referred to as a "bond breaker".
Key Parameters in Design

- A punchout commonly initiates in conjunction with
  - Excessive erosion of the support between two closely spaced transverse cracks.
  - The natural opening and closing of cracks is caused by temperature and moisture changes in the slab.
  - There is also a tendency of the aggregate interlock along the transverse crack to wear out under traffic. This results in a loss of load transfer.
Design Features

Modified #53 Stone

Special filter fabric
Design Features

Dense graded base

Illinois System
Transverse Reinforcement

**Functions**

- Tie bars across longitudinal joints
- Keeps potential longitudinal cracks held tight
- Supports longitudinal steel in place
MEPDG Design

Design Structure

<table>
<thead>
<tr>
<th>Layer type</th>
<th>Material Type</th>
<th>Thickness (in.)</th>
<th>Steel Reinforcement:</th>
</tr>
</thead>
<tbody>
<tr>
<td>PCC</td>
<td>CRCP Default</td>
<td>11.0</td>
<td>Steel (%) 0.80</td>
</tr>
<tr>
<td>Flexible</td>
<td>Asphalt concrete</td>
<td>3.0</td>
<td>Bar diameter (in.) 0.88</td>
</tr>
<tr>
<td>NonStabilized</td>
<td>Crushed stone</td>
<td>6.0</td>
<td>Steel depth (inch) 3.50</td>
</tr>
<tr>
<td>Subgrade</td>
<td>A-6</td>
<td>14.0</td>
<td></td>
</tr>
<tr>
<td>Subgrade</td>
<td>A-7-6</td>
<td>Semi-infinite</td>
<td></td>
</tr>
</tbody>
</table>

Traffic

<table>
<thead>
<tr>
<th>Age (year)</th>
<th>Heavy Trucks (cumulative)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2014 (initial)</td>
<td>10,598</td>
</tr>
<tr>
<td>2034 (20 years)</td>
<td>21,744,300</td>
</tr>
<tr>
<td>2054 (40 years)</td>
<td>47,460,200</td>
</tr>
</tbody>
</table>

Design Outputs

Distress Prediction Summary

<table>
<thead>
<tr>
<th>Distress Type</th>
<th>Distress @ Specified Reliability</th>
<th>Reliability (%)</th>
<th>Criterion Satisfied?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Terminal IRI (in./mile)</td>
<td>160.00 144.35</td>
<td>90.00 97.05</td>
<td>Pass</td>
</tr>
<tr>
<td>CRCP punchouts (1/mile)</td>
<td>10.00 6.21</td>
<td>90.00 98.60</td>
<td>Pass</td>
</tr>
</tbody>
</table>

Distress Charts

- Predicted IRI
- Predicted Punchout
End Anchors Construction

- To accommodate pavement growth
- If uncontrolled, may close the expansion joint in the approach to structures and induce damage to the adjacent structure.
End Anchors Construction

[Diagram of construction details]

[Images of construction sites]
Base Layer Construction

- Asphalt dense graded layer
- Pumping of support layer material through CRCP cracks and joints
  - Punchchout formation.
- Non-erodible, impermeable materials
  - CRCP subjected to heavy traffic loads to minimize pumping
  - The base layer provides a stable platform during construction.
Subbase Layer Construction

- Modified #53 stone
  - Open-graded drainable base under CRCP has an issue with friction and pumping
  - High water table and drainage is needed to provide enough pavement support
Special Geotextile Construction

- Geotextile with appropriate permittivity value
  - Avoid clogging
  - As separator layer with the subgrade
- Subgrade pumping into the permeable base material is the issue.
Subgrade Consideration

- The performance of any pavement
  - Affected by the support provided by the subgrade
  - Subgrade provides uniform support not affected by
    - Moisture variations
  - Adequate drainage and stabilization of the subgrade materials as required
Questions???

DIPLOMACY
You're either part of the steamroller or part of the pavement.
...I kid! You're part of the pavement.