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.
Introduction to CRCP

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

Steel Stress x 10^3 psi

Crack Width x 10^-2 (in.)

Crack Spacing (ft)

Maximum Crack Spacing

Allowable Steel Stress

Allowable Crack Width

Minimum Crack Spacing

Acceptable Design

% Steel Reinforcement
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>
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<tr>
<td>NonStabilized</td>
<td>Crushed stone</td>
<td>6.0</td>
<td>Steel depth (inch) 3.50</td>
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<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>
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</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</td>
<td>90.00</td>
<td>97.05</td>
</tr>
<tr>
<td>CRCP punchouts (1/mile)</td>
<td>10.00</td>
<td>90.00</td>
<td>98.60</td>
</tr>
</tbody>
</table>

### Distress Charts

1. **Predicted IRI**
   - Threshold Value: 144.35
   - Initial IRI: 70

2. **Predicted Punchout**
   - Threshold Value: 10
   - Initial Punchout: 0.90

oscope
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
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
End Product
Questions???

DIPLOMACY

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