SHRP 2 Renewal
Long Life Composite Pavement Systems

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Presentation

• Definition composite pavement
• Composite Long Life Examples
• Developed Products SHRP R-21
• Benefits Long Life Composite Pavements

Two Types Composite Pavements

HMA, Porous HMA, SMA, ARFC / JPCP, CRCP, RCC

PCC/JPCP: Wet on Wet

R21: Composite Pavements and SHRP2 Renewal

Renewal Mission: “Get in, Get out, Stay out”

– Upper layer (HMA or PCC)
  – Primarily a functional layer
  – Can be rapidly renewed (if needed) with minimal disruption to traffic
    • Retexturing (grinding for PCC)
    • Remove and replace surface layer (for HMA)
  – Higher quality materials (aggregate, binder, cement content, etc.) for increased life
  – Very good surface characteristics (smoothness, friction, noise, durability)

– Lower layer (PCC)
  – Primary structural layer
  – Designed for minimal fatigue damage (no fatigue cracking)
  – Produces long-lived structure
  – Can be designed with lower cost materials (recycled materials, aggregates, lower cement content, high cement replacement, limited RAP, etc.)

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Florida US 41 PCC/PCC
- Age: 30-years, 5 million trucks / lane
- 3-in PCC / 9-in PCC (fully bonded)
  - Top layer: Normal strength/texture PCC
  - Lower layer: Lower strength PCC
- 15 & 20-ft joint spacing
- Doweled and non-doweled joints
- Performance: minor cracking & faulting
- Maintenance: minor only

Austria A-1 PCC/PCC
- Age: 14 to 20-years, 47+ million trucks / lane
- 2-in PCC / 8-in RCA w/RAP (fully bonded)
  - Top layer: Higher strength PCC
  - Lower layer: Normal strength PCC
- 18-ft joint spacing
- Doweled joints
- Performance: no cracking or faulting
- Maintenance: minor only
Germany A-93 PCC/PCC

- Age: 13-years, 53 million trucks / lane
- South of Munich, Germany
- 3-in PCC / 7.5-in PCC (fully bonded)
  - Top layer: Higher strength PCC
  - Lower layer: Normal strength PCC
- 16-ft joint spacing
- Doweled joints
- Performance: no cracking or faulting
- Maintenance: minor only

Netherlands N-279 PCC/PCC

- Age: 8-years, 12 million trucks / lane
- 3.5-in PCC / 7-in PCC (fully bonded)
  - Top layer: Higher strength PCC
  - Lower layer: Normal strength PCC
- 15-ft joint spacing
- Doweled joints
- Performance: no cracking or faulting
- Maintenance: minor only

Presentation

- Definition composite pavement
- Composite Long Life Examples
  - Developed Products
  - Benefits
R21: Products – 1. Design

(a) Revisions of the AASHTO MEPDG software program – MEPDG version R21.1.3

- Numerous bugs fixed, modifications to PCC layer thicknesses, PCC layer properties, slab and base interaction properties (full vs. zero friction), PCC/PCC subgrade response modeling, & distribution of temperature nodes representing a thermal gradient through composite pavement system.
- Calibrated structural and performance models for key distresses in composite pavements.
- Recommended design inputs.

Calibration Results HMA/JPCP (Transverse Fatigue Cracking)

Can design HMA/JPCP using DARWin-ME

(b) Revisions to the Manual of Practice (MOP)

- List of revisions (how to design composite, inputs)
- Where the revisions should be inserted into the MOP
- MOP revisions include composite pavement design examples

(c) Life-Cycle Cost Analysis (LCCA) guidelines and examples

- Guidelines for performing LCCA to compare composite and conventional pavements (Mn contractor analysis)
- Guidelines using FHWA RealCost and examples

PCC/PCC Composite Pavements and Costs

- MnROAD Contractor’s Assessment
- Implementation of a 2-layer Composite Paving process would be a viable and competitive alternative to Conventional Paving, if:
  - Class A aggregates aren’t readily available.
  - High haul times drive the price of the aggregates too high.
  - Recycled Concrete could be produced on or near the site.
  - Haul times would have to be cut to minimal levels.
  - Should have to produce recycled at about 60% the cost of Class A.
  - You were capable of producing and paving at an equal rate to conventional paving (using two pavers).
- Lower life-cycle costs
  - Rapid renewal, lower maintenance and rehabilitation, long-life
R21: Products – 2. Construction and Materials

(a) Construction Specifications (Specs.)

- Material specs. – cementitious (cement, flyash), asphalt binder, aggregate type and gradation, etc.
- Procedural specs. – two-lift wet-on-wet construction, timing, texturing, saw-cutting & sealing, tack coat application (HMA/PCC), etc.

(b) Construction Guidelines and Quality Management (QM) Procedures

- Two-lift wet-on-wet construction timing and sequencing, surface brushing & texturing procedures and guidelines, paving low-slump stiff concrete, paving thin upper lift, recycling existing pavement, and other operational issues

(c) Material Guidelines

- Material selection guidelines for cementitious materials (cement, flyash), asphalt binder, aggregate type and gradation (considering durability issues for both lower lift and upper lift), using recycled aggregates, retarding/curing compound.
- PCC RILEM 176 CIF freeze/thaw testing

R21: Products – Final Report

- Vol. A: HMA/PCC Composite Pavement
- Vol. B: PCC/PCC Composite Pavement
- Vol. C: Appendices A through W: Background composite pavements; US/Canada/European survey results; European field summary; distress mechanisms, construction MnRoad & UCPRC, instrumentation, rutting, slab temperatures, HMA cracking, joint movement, HMA & PCC lab tests, HMA bonding & friction, CALME, MEPDG modifications, Lattice 3D model, recycled PCC, new freeze-thaw PCC testing, brushing exposed aggregate concrete
- Vol. D: Appendix X (Specifications) & Y (revisions AASHTO Manual Practice)

R21: Products – Other

(a) MnROAD Test Sections

- Three full-length two-lane test sections constructed at MnROAD in Albertville, MN on Interstate 94
- Construction in April/June 2010, open to traffic in July
- Currently being monitored (instrumentation, field surveys, other field testing)
R21: Products – 5. Other

(b) UCPRC HVS Test Sections

- 12 45-ft 1-lane wide test sections
- Currently being monitored (instrumentation) and tested with the HVS
- Channelized half-axle dual-wheel loading – rutting, reflection cracking, PCC fatigue cracking

PCC/PCC Composite Pavements and Performance

<table>
<thead>
<tr>
<th>Distress Type</th>
<th>Conventional JPCP &amp; CRCP</th>
<th>Composite PCC/JPC &amp; PCC/CRC Pavement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bottom-Up Slab Fatigue Cracking</td>
<td>Yes, major design concern.</td>
<td>Yes, major design concern.</td>
</tr>
<tr>
<td>Top-Down Slab Fatigue Cracking and Top-Down Fatigue Cracking and Corner Breaks</td>
<td>Yes, major design concern.</td>
<td>Yes, has occurred on some projects. No, was not observed on any PCC/PCC composite project. Higher strength PCC surface layer may be beneficial.</td>
</tr>
</tbody>
</table>

R21: Products – 5. Other

(d) Lattice Model (PCC/PCC Debonding)

- Completed work coupled the lattice models with finite element models to provide a comprehensive model of the PCC/PCC interface bonding.
- Analysis concluded wet on wet paving had only very low chance if any to debond, matching field surveys & bond testing.

PCC/JPCP Composite Design
Versus Single Slab
I-94 Albertville, Minnesota (10 M trucks)

<table>
<thead>
<tr>
<th>Design</th>
<th>PCC/PCC Composite</th>
<th>JPCP</th>
</tr>
</thead>
<tbody>
<tr>
<td>PCC Surface</td>
<td>3-in PCC</td>
<td>None</td>
</tr>
<tr>
<td>JPCP</td>
<td>H = 6 in RCA Dowels = 1.25 in</td>
<td>H = 8.75 in PCC Dowels = 1.25 in</td>
</tr>
<tr>
<td>Base</td>
<td>8-in Untreated Aggregate</td>
<td>8-in Untreated Aggregate</td>
</tr>
<tr>
<td>Reliability</td>
<td>&gt;90%</td>
<td>&gt;90%</td>
</tr>
</tbody>
</table>

PCC/JPCP Composite Design
Versus Single Slab
I-70, Abilene, Kansas (21 M trucks)

<table>
<thead>
<tr>
<th>Design</th>
<th>PCC/PCC Composite</th>
<th>JPCP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Surface</td>
<td>1.5-in PCC</td>
<td>None</td>
</tr>
<tr>
<td>JPCP</td>
<td>H = 11.8 in Dowels = 1.5 in</td>
<td>H = 13 in Dowels = 1.5 in</td>
</tr>
<tr>
<td>Base</td>
<td>8-in Untreated Aggregate</td>
<td>8-in Untreated Aggregate</td>
</tr>
<tr>
<td>Reliability</td>
<td>&gt;90%</td>
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### Long Life Composite Pavement Benefits

<table>
<thead>
<tr>
<th>Benefit</th>
<th>PCC / PCC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Get in / Get out</td>
<td>Long life surface, but PCC top surface can be restertextured rapidly</td>
</tr>
<tr>
<td>Long fatigue life</td>
<td>Top &amp; Bottom PCC layer designed for low structural fatigue damage &amp; cracking</td>
</tr>
<tr>
<td>Life cycle cost</td>
<td>Equivalent or less than conventional HMA or PCC, but very cost-effective where quality aggregates are scarce</td>
</tr>
<tr>
<td>Reflection cracking</td>
<td>Does not exist</td>
</tr>
<tr>
<td>Scarcely costly aggregate</td>
<td>Lower cost aggregate used in lower thicker PCC layer</td>
</tr>
<tr>
<td>Surface characteristics advantage</td>
<td>Hard high quality aggregate. Diamond grinding &amp; EAC provides low noise, high friction, smoothness, low polish, thus longer life</td>
</tr>
</tbody>
</table>