Cold Central Plant Recycled Pavements (CCPR)

Dr. David Timm, P.E.
Background

- RAP usage common
  - 81.8 million tons in 2016
  - Majority used in HMA or WMA
- Opportunity to use RAP with cold recycling techniques
  - Fewer virgin materials
  - Less fuel consumption
  - Fewer emissions
  - Faster construction time
- Cold RAP (2016) = 0.2 million tons
Cold Central Plant Recycling

- Milling
- Fractionation
- CCPR Mixing (RAP+recycling agents)
- Conventional Paving
Structural Characterization of CCPR

- No current specific methodology for determining structural characteristics
  - Some studies evaluated fundamental characteristics
  - Very little study under heavy traffic conditions
  - Need a structural coefficient (0.36 to 0.39 is conservative)
VDOT Experience

- **2011:** I-81
  - CIR, FDR & CCPR
  - 6000 Trucks/Day
- **2012:** NCAT Test Track
  - CCPR and Stabilized Base Sections
  - 10 million ESALs/Test Cycle
- **2016:** I-64
  - CCPR and Stabilized Base
Objectives & Scope of Work

- **Objectives**
  - Document performance of Test Track sections
  - Evaluate Test Track sections using perpetual criteria

- **Scope of Work**
  - Three test sections over two cycles at Test Track
  - Accelerated trafficking (20 million ESALs)
  - Weekly performance measurements
  - Frequent FWD testing
  - Measurements from embedded instrumentation
  - Perpetual pavement analysis
Cross Sections

N3-6" AC

N4-4" AC

S12-4" AC SB

CCPR-97% RAP with 2% Foamed 67-22 and 1% Type II Cement

6" Crushed granite aggregate base and 2" subgrade stabilized in-place with 4% Type II cement

Depth, in.

0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20

SMA

Superpave

CCPR

Stabilized Base

Aggregate Base

Subgrade

Asphalt Strain Gauges

Temperature Probe

Earth Pressure Cell
### Layer Parameters

<table>
<thead>
<tr>
<th>Section</th>
<th>N3-6”AC</th>
<th>N4-4”AC</th>
<th>S12-4”AC SB</th>
</tr>
</thead>
<tbody>
<tr>
<td>Layer Description</td>
<td>Lift 1-19 mm NMAS SMA with 12.5% RAP and PG 76-22 binder</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Binder Content, %</td>
<td>6.1</td>
<td>6.0</td>
<td>6.1</td>
</tr>
<tr>
<td>$G_{mm}$</td>
<td>95.7</td>
<td>95.3</td>
<td>95.8</td>
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<tr>
<td>Layer Description</td>
<td>Lift 2-19 mm NMAS Superpave with 30% RAP and PG 67-22 binder</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Binder Content, %</td>
<td>4.6</td>
<td>4.6</td>
<td>4.7</td>
</tr>
<tr>
<td>$G_{mm}$</td>
<td>92.9</td>
<td>7.4</td>
<td>93.3</td>
</tr>
<tr>
<td>Layer Description</td>
<td>Lift 3-19 mm NMAS Superpave with 30% RAP and PG 67-22 binder</td>
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<td></td>
</tr>
<tr>
<td>Binder Content, %</td>
<td>4.4</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>$G_{mm}$</td>
<td>93.6</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>Layer Description</td>
<td>CCPR-97% RAP with 2% Foamed 67-22 and 1% Type II Cement</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Layer Description</td>
<td>Crushed granite aggregate base</td>
<td>6” Crushed granite aggregate base and 2” subgrade stabilized in-place with 4% Type II cement</td>
<td></td>
</tr>
<tr>
<td>Layer Description</td>
<td>Subgrade – AASHTO A-4 Soil</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Construction
Performance Measurements

- Weekly inspection for cracking
- Weekly rut and ride quality
FWD Testing & Backcalculation

- Several tests/month
- Dynatest 8000 FWD
  - Nine sensors
- Three replicates at four drop heights
- Backcalculation with EVERCALC 5.0
Cracking Performance @ 20 MESALs

N3-6”AC

S12-4”AC SB

N4-4”AC
Rutting Performance

The graph illustrates the rutting performance over time, with data points for different AC thicknesses (N3-6"AC, N4-4"AC, S12-4"AC SB) and ESALs. The x-axis represents the date, ranging from October 1, 2012, to November 14, 2017. The y-axis shows the rut depth in inches, ranging from 0.00 to 0.50. The graph includes two test cycles: 2012 and 2015, with a break between them. The ESALs line shows a steady increase in rut depth over time.
Backcalculated Modulus vs Temp

[Graph showing backcalculated AC/CCPR modulus vs mid-depth temperature with equations for N3-6"AC, N4-4"AC, and S12-4"AC SB.

- N3-6"AC: $y = 3459.5e^{-0.027x}$, $R^2 = 0.6139$
- N4-4"AC: $y = 1720.6e^{-0.019x}$, $R^2 = 0.785$
- S12-4"AC SB: $y = 2822.8e^{-0.013x}$, $R^2 = 0.1699$]
Backcalculated Modulus @ 68F

Backcalculated AC Modulus, ksi

Date

2012 Test Cycle

Break Between Test Cycles

2015 Test Cycle

Million ESALs

N3-6" AC

N4-4" AC

S12-4" AC SB

Linear (N3-6" AC)

Linear (N4-4" AC)

Linear (S12-4" AC SB)

y = -0.0198x + 1436.5

y = -0.0039x + 642.03

y = 0.1261x - 4026.5

R² = 0.0036

R² = 0.0006

R² = 0.0171

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Strain Versus Temperature

- N3-6"AC
- N4-4"AC
- S12-4"AC SB

Expon. (N3-6"AC): $y = 44.811e^{0.0279x}$, $R^2 = 0.8459$
Expon. (N4-4"AC): $y = 95.283e^{0.023x}$, $R^2 = 0.711$
Expon. (S12-4"AC SB): $y = 54.105e^{0.0132x}$, $R^2 = 0.5674$
Perpetual Pavement Analysis – As Built

**Measured**

**Simulated** *(PerRoad)*
Additional Perpetual Analysis

![Graph showing cumulative percentile vs. simulated tensile microstrain for different samples labeled as N3-As Built, N3+2", N3+2.5", N3+3", PerRoadLimit, S12-4", S12-6", and S12-As Built.](image)
Caution with Stabilized Base

Horizontal Microstrain

Depth Below Pavement Surface, in.

CCPR/Stabilized Base Interface

Bottom of Stabilized Base

Tension

Compression

S12-6"
S12-4"
S12-AsBuilt
Conclusions & Recommendations

• Excellent performance from all sections
  ▶ Outperformed expected lives (> 16 Million ESALs)
• Treat CCPR like AC in mechanistic modeling
  ▶ Supported by FWD and strain measurements
• S12 Expected to be perpetual using current criteria
  ▶ Leave in place to apply additional traffic
• N3 and N4 expected to crack at some point?
  ▶ Leave N4 in place to apply additional traffic
Thank you!

Questions?
Reach me at
timmdav@auburn.edu

2018 NCAT Test Track Conference