Cold In-Place Recycling (CIR)

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Outline

• What is CIR?
• MN & National CIR Use
• Project Use
  • Challenges (Lessons Learned)
  • Successes
• Summary
In-Place Recycling Terms

**Full Depth Reclamation (FDR)**
- Grind HMA with Base

**Stabilized FDR (SFDR)**
- Grind HMA with 1 to 2 inches of Base & add additive (liquid or dry)

**Cold-in Place Recycle (CIR)**
- Grind HMA ONLY & add liquid additive (can add dry too)
Cold In-Place Recycling

- Partial depth (2 - 4”) of HMA (No Heat).
- Uses mill, crushing and screening units, pavers, mixers & rollers
- Typically leaves a small amount (~1”) of HMA for equipment Support
CIR Equipment

1. Mill Pavement
2. Process (Screen & Crush) RAP Material
3. Mix Processed RAP with Additives
4. Place & Compact CIR
CIR Train in North Dakota
TH 21, Barnes County, ND

- Rural 2-lane, South of Valley City
- CIR 4” @3.2% Emulsion + Granite Chips
- Chip Seal Surface Treatment
2012 Performance

2 Sections Perform well after 3 or 5 yrs

Some reflective cracking (trans./long.)
(Survived floods of 2010)
National CIR Use

• Nat’l. Recycling Center in CA, sponsored by ARRA
• Several 20 Year Performance Reports: NM, WA, PA, NV, NY
• Upcoming NHI Class: “Asphalt Pavement In-Place Recycling”
• Ontario & IA have inspired MN Specs.
MN CIR Use

• Ramsey & Other Counties in Mn used for ‘many years’

• MnDOT Inconsistent Use
  • Late 80’s Early 90’s Started, then pulled back due to issues
  • One District ~ 100 miles
  • Starting to be Used Again
MNDOT CIR Issues

- Rutting
  - Material Choice? Thickness?
  - Did Mix Designs, then stopped because all came back at 2.0% add oil

- Cure Times (Before Overlay)
  - Material Choice?
County Continued CIR Use

- Used MnDOT Specs
- Equipment Requirements
  - Closed Loop System Screened, Crushed => Consistent Product
  - Oil Added based on Weight
- Better Mix Design
- Engineered Emulsion => Cure Times, Strength
MN Use of CIR

- 2010: MnDOT Innovation Money: 5 Stabilized FDR + 2 CIR projects in last two years
- One upcoming State project (No Innovation Money)
- County Project: CIR with Engrd. Emulsion & Cement, Chip Seal Surface
TH 27: Project Overview

• Rural 2-lane with 1,400 ADT
• 16+ Miles of CIR ($\frac{1}{2}$ Emulsion + $\frac{1}{2}$ Foam)
• Mill 2", CIR 4" (2" In-Place), 3.5" HMA

IRI: 150’s - 220+ Patching Cracking
TH 67: Project Overview

- Rural 2-lane with 1,400 ADT
- 8+ Miles of CIR (Engr. Emulsion)
- Mill 4”, CIR 4” (4” In-Place), 4” HMA

IRI: 130’s - 150+ Patching
WP Cracking
TH 27: 2 Sections

- HFMS-MP (Emulsion) @2% (No Design)
- Foamed AC @2% (Mix Design)
Foamed Oil / Emulsion

Emulsion ~ 33% H₂O + 67% Oil (2%=1.3%)

Foamed AC ~ 100% Oil (2%=2%)
Foamed AC

Measure the foaming properties
Compare against Design, & Adjust
TH 27: Foamed Mix Design

- Used IA Procedure (Modified Wirtgen)
- Indirect Tensile Strength (Dry/Wet) 66 / 46 (70% Retained)
- Fines Needed? (Too Much = Bad)

[Graph showing the gradation of blended materials]
## TH 67: Emulsion Mix Design

<table>
<thead>
<tr>
<th>Property</th>
<th>Criteria</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>Compaction effort, Superpave Gyratory Compactor</td>
<td>1.25° angle, 600 kPa stress, 30 gyrations Report</td>
<td>Density indicator</td>
</tr>
<tr>
<td>Density, ASTM D 2726 or equivalent</td>
<td>Report</td>
<td>Compaction indicator</td>
</tr>
<tr>
<td>Retained stability based on long-term stability</td>
<td>70% min.</td>
<td>Resistance to moisture damage</td>
</tr>
<tr>
<td>Marshall stability, ASTM D 1559 Part 5, 40°C</td>
<td>1,250 lb min.</td>
<td>Stability indicator</td>
</tr>
<tr>
<td>Raveling test, ASTM D 7196-06</td>
<td>2% max.</td>
<td>Resistance to raveling</td>
</tr>
<tr>
<td>Indirect tensile test, AASHTO T322, Modified</td>
<td>LTPPBind temperature for climate &amp; depth</td>
<td>Resistance to cracking</td>
</tr>
</tbody>
</table>
Mix Design: Stability Test

- Resistance to Plastic Flow
- Average Retained Strength ⇒ Moisture Sensitivity
Mix Design: Raveling Test

- Evaluate Emulsion/ RAP compatibility
- ASTM D 7196-06 (2% Loss Max.)

1% Loss after 15 minutes

11% Loss after 10 minutes
TH 67: Emulsion Mix Design

- Dry Stability: 1,682 lbs.
- Retained Stability: 1,441 lbs. (85%)
- Raveling Test: 0.86%
- Indirect Tensile: -32°C (Cracking)

<table>
<thead>
<tr>
<th>RECOMMENDATION (See Conclusion Below)</th>
<th>Based on 12 ft. width</th>
<th>gal/ft</th>
<th>gal/SY</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.3% +/- 0.3%</td>
<td>for 3 in. depth</td>
<td>1.47</td>
<td>1.11</td>
</tr>
<tr>
<td>1.5% +/- 0.5%</td>
<td>for 4 in. depth</td>
<td>1.96</td>
<td>1.47</td>
</tr>
</tbody>
</table>
Q/C & Q/A

- Depth
- Gradation
- Yield (Asphalt Binder)
- Moisture
- Establishing Rolling Patterns (Nuke)
Check Depth & Gradation

- Depth - Adjust to Ensure Adequate Support
- 100% passing 1.5”; 90-100% passing 1.0”
Monitor Oil Addition Rate

- Too Much => Rutting issues, $$
- Too Little => Failures, Raveling, Durability
- Affected by Temperature & Gradation
Observe Test Strip

- Use Nuke Device
- Check Density (Info. Only)
- New Test Strip if “Changes"

6 - 8 Passes to break down

Finish Roll Until: Density Breaks or no change
Curing

- Moisture $\leq 1.5\%$ (weight) $\sim 7 - 10$ days before placing HMA.
- If Moisture $> 1.5\%$ & $< 2.5\%$ & has not changed by more than 0.2% over five days, the Engineer may allow HMA Placement.
- Fog Seal to prevent raveling if open for extended period of time.
Drainage

Recycling will find weak/poor areas

• Recycling does not fix Soft Spots
TH 27 Won a Paving Award

Another project to be built this year
Cost Information

Two Items (SY & Ton)

- ~$1.70 / SY CIR Bit. Mixt.
- $535 - $683 / TON Oil
  - $35,700 for Lane*Mile 4” CIR
  - $38,600 for Lane*Mile 2” HMA

- Relaxing equipment Requirements
  Reduced Prices => $.04/SY
CIR Keys to Success

- Conduct Pre-Project Evaluations
  - Existing Pavement Thickness (GPR all Projects)
  - Drainage Evaluations
  - Subgrade/Support Conditions
- Conduct Mix Designs
  - Evaluate potential products
  - Apply at Proper rates
CIR Keys to Success

Measure & Observe During Project

• Gradation

• Bituminous Material

• Addition Rate, Foaming Properties (if applicable)

• Density – Establish a rolling pattern using nukes & continuously observe
Thank You!

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