Iowa’s Best Practices for Full Depth Reclamation and Cold In-Place Recycling

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Experience with In-Place Recycling

- Cold-in-place Recycling (foam and emulsion)
  - 5-year Total
    - 53 projects
    - $118M
    - 1800 lane-miles
  - Many more local CIR projects
- Full Depth Reclamation (fly ash stabilization)
  - 5-year Total
    - 3 Projects
    - $8.6M
    - 100 lane-miles
Iowa Field Performance

Average High Severity Transverse Cracking
10 Year Span (3-4 inches HMA Surface)
Why Not More?

- Traffic limitation (CIR < 2,000 VPD)
- Only works with adequate structure
- Risk when left open to high traffic
- Overcome with KNOWLEDGE!
Common Questions

• When CIR?
  ▫ Ideal candidate?
  ▫ Mix Design?
  ▫ Foam or Emulsion?
  ▫ When to overlay?
  ▫ Quality control/Quality assurance?

• When FDR?
  ▫ Ideal candidate?
  ▫ Stabilization?
  ▫ Mix Design?
  ▫ Quality control/Quality assurance?
Project Evaluation

- Traffic
- Structure
- Distress
- Climate

CIR (2-4”)
FDR (6-12”)
Cold In-Place Recycling

- ≤ 2,000 ADT
  - At least 8" thickness (3" HMA)
  - Adequate structural support
  - Surface distress
    - Good candidate

- > 2,000 ADT
  - Can still be successful

Project evaluation
- FWD, DCP, Coring

Recycling
Project Evaluation

(Pleasant Creek State Park Data)
CIR – Mix Design

- Need RAP samples
  - REPRESENTATIVE = DIFFICULT
  - Milling 50’ at 3 locations (preferred)
  - Coring or air hammer patching
CIR – Foam Mix Design

1. Determine Optimum Foaming Binder (PG 52-34 or PG 46-34)
   280-320°F
   1.5% - 3.5% water injection
   Target Half life and Expansion Ratio ~10

2. Determine Optimum Moisture Density Curve (Proctor)
   Experience > 4% optimum (adjusted for foaming water)

3. Compact specimens @ 4 foamed AC contents
   1.5, 2.0, 2.5, 3.0%
   N=45 gyrations

4. Optimize AC foam content from IDT results
CIR – Emulsion Mix Design

• HFMS-2s (interstate and primary)
• CSS1 (other projects)
• 100+ mix designs
• ~0.3 gallons/yd²
• Engineer may adjust rate to improve stability
Foam OR Emulsion?

• Does it matter????
• ……..Sometimes….
• Stabilizing agent will impact curing > OVERLAY
• The magnitude of impact is material dependent
Curing – Indirect Tensile Strength

![Image of graph showing indirect tensile strength versus moisture content for different materials. The graph indicates that indirect tensile strength decreases with increasing moisture content, with a notable decrease around 1.5% moisture.]
Curing – Flow Number (Foam #1)

Cumulative Strain (%) vs Loading Cycles

- 0day #2, 0day #1, (1.23%), (1.18%)
- 7days #2, 14days #2, (1.24%), (1.14%)
- 7days #1, 14days #1, (1.13%), (1.09%)

( ) Moisture Content

Legend:
- 0day #1
- 0day #2
- 7days #1
- 7days #2
- 14days #1
- 14days #2
Curing – Flow Number (Emulsion #1)
Curing – Flow Number (Foam #2)
Curing – Flow Number (Emulsion #2)

Cumulative Strain(%) vs Loading Cycles

- 0day #1
- 0day #2-N/A
- 7days #1
- 7days #2
- 14days #1
- 14days #2

( ): Moisture Content

- 0day #1: [Graphical representation]
- 0day #2-N/A: [Graphical representation]
- 7days #1: [Graphical representation]
- 7days #2: [Graphical representation]
- 14days #1: [Graphical representation]
- 14days #2: [Graphical representation]
Curing – Flow Number (Foam #3)

Cumulative Strain (%) vs. Loading Cycles

0day #2, (1.18%), 14days #2, (1.27%), 7days #2, (1.35%), 0day #1, (1.21%), 7days #1, 14days #1, (1.25%), (1.33%)

(): Moisture Content

Legend:
- 0day #1
- 0day #2
- 7days #1
- 7days #2
- 14days #1
- 14days #2
Curing – Flow Number (Emulsion #3)

Cumulative Strain (%) vs. Loading Cycles

- 7 days #2, 14 days #1, 0 day #1, 14 days #1, (1.95%) (1.51%) (1.35%)
- 14 days #2, (1.21%)
- 7 days #1, (1.60%)
- 0 day #2, (1.59%)

( ): Moisture Content

Legend:
- ▲ 0 day #1
- ○ 0 day #2
- ◇ 7 days #1
- ▲ 7 days #2
- □ 14 days #1
- □ 14 days #2
Curing – Dynamic Modulus

![Graph showing the dynamic modulus of different samples over time and moisture content. The graph includes four sets of data, each represented by different symbols and colors. The x-axis represents curing time in hours, ranging from 0 to 100. The y-axis represents dynamic modulus at 21.1°C in GPa, ranging from 0 to 5.0. The moisture content is indicated for each data point.]
Foam or Emulsion?

- 12-month price history (2/2010 – 2/2011)
- Foam
  - $530/ton
  - $0.58 - $0.70 per yd$^2$-in
- Emulsion
  - $1.88/gal
  - $0.49 - $0.66 per yd$^2$-in
- CIR
  - $1.30 - $2.10/yd$^2$
Average High Severity Transverse Cracking
10 Year Span (3-4 inches HMA Surface)
Cold In-Place Recycling

- Iowa is a leader in CIR
- IHRB Project (University of Iowa)

Acknowledgement: David Lee

Stage 1: Lab evaluation
Stage 2: Curing model (moisture)
Stage 3: Curing criteria (stiffness gain)

GeoGauge:
- 22 lbs
- Applies sinusoidal loading and measures deflection
- 3 to 70 MN/m
Iowa DOT Specifications

- Mix Design
  - Foam: 0.0011 tons/yd$^2$-in
  - Emulsion: 0.30 gallons/yd$^2$-in
- CIR allowed May 1 – October 1
  - 60F and rising
- Quality Assurance (Nuclear Gauge)
  - 94% density (primary)
  - 92% density (other)
- Overlay
  - <2% moisture (or 0.3% of residual moisture)
  - Then 14 calendar days to complete overlay
Hwy 78 Keokuk County (2000)
Hwy 78 Keokuk County (5 years)
Hwy 78 Keokuk County (7 years)
Hwy 78 Keokuk County (9 years)
Webster County 175

- 2009 Construction
- 9” FDR + 3” HMA (2011 = NO DISTRESS)
- 3” CIR + 3” HMA (2011 = NO DISTRESS)
- 2” CIR + 3” HMA (2011 = Few trans. cracks)
- Mill 3” + 3” HMA (2011 = Reflective Cracks)

<table>
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<th>Test</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
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<tr>
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<td>3.3</td>
<td>2.7</td>
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<td>2.9</td>
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<td>3.0</td>
<td>2.7</td>
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<tr>
<td>Thickness, in</td>
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<td>7.5</td>
<td>10.0</td>
<td>7.5</td>
<td>9.0</td>
<td>6.8</td>
<td>9.5</td>
<td>10.3</td>
<td>8.3</td>
<td>8.5</td>
<td>8.0</td>
<td>7.8</td>
</tr>
</tbody>
</table>

Hwy 175 Webster County (Pre-CIR)
Hwy 175 Webster County (CIR)
Hwy 175 Webster County (CIR 2 years)
Hwy 175 Webster County (Pre-FDR)
Hwy 175 Webster County (FDR)
Hwy 175 Webster County (FDR 2 years)
Hwy 175 Webster County (Pre-Mill)
Hwy 175 Webster County (Milled)
Hwy 175 Webster County (2 years)
Hwy 175 Webster County (Overlay)
Keys to Successful Future Projects

• Right time + Right place + Right project
• Don’t blame the technology!
Thank you