PERFORMANCE OF COLD IN PLACE RECYCLING IN NEVADA

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Recycling

- Reduced Cost
- Less Waste
- Effective in Reducing Reflective Cracking
- Reduced Overlay Thickness
Cold-In-Place Recycling (CIR)

- Full Depth: HMA + some Base
- Partial Depth: Portion of HMA Base under Low-Medium Traffic
Schematic of Single Pass Equipment Train

- Pavement Profiler
- Crusher/Screen
- Pugmill
- Paver
Multi-Unit CLR Train
Previous Experience

• Blue Earth County, MN, 2001: New engineered process improved long term durability and better resistance to thermal cracking

• Brayton et al., 2001: A Superpave Volumetric Mix Design for CIR
Previous Experience

- **Saskatchewan DOT, 2002**: CIR was very effective in strengthening under-designed pavements.

- **New Mexico DOT, 1997**: Polymer-modified high float emulsion improved resistance to early rutting and resistance to moisture damage.
Objective

- Develop a Mix Design for CIR
- Construct Field CIR Projects
- Monitor Performance of CIR Projects
Mix Design for CIR

• Reduce Brittleness of the Aged Existing Mixture
• Control the Compactibility of the CIR Mixture
• Provide Good Stability for Early Traffic
• Improve the Moisture Sensitivity of the Mixture
Distresses Treated with CIR: Block Cracking
Distresses Treated with CIR: Thermal Cracking
Distresses Treated with CIR: Raveling
Distresses Treated with CIR: Potholes
Mix Design for CIR

• Hveem Mix Design Process
• Supplemental Steps:
  o Properties of In-Place Mixture
  o Optimum Moisture Content
  o Stability at Various Stages
  o Moisture Sensitivity
In-Place Mixture

- No Binder-Aggregate Separation
- Mr at 77°F a Measure of Brittleness
  - Mr at 77°F > 1,000 ksi  Aged & Brittle
  - Mr at 77°F: 300-500 ksi  New HMA Mix
- Objective: Take a Mix with Mr > 1,000 ksi and Reduce it to Mr of 200-500 ksi
Stability at Various Stages

- **Initial Curing:** Early and Construction Traffic – In-Mold at 77°F for 15 hrs
- **Final Curing:** Stability during Service – Out of Mold at 140°F for 3 Days
- **Long-Term Curing:** Check for the Long-Term Brittleness – Out of Mold at 140°F for 30 Days
Moisture Sensitivity

- AASHTO T-283
- Mr instead of TS
- Lime Additive
Mr Testing Machine  ASTM D4123
CIR Core vs. HMA Core
Field Projects

- 1997-1998: 3 Projects
  - US50: CIR top 2” + 2” HMA Overlay + ¾” OG
  - US95: CIR top 3” + 3” HMA Overlay + ¾” OG
  - SR396: CIR top 2” + 2” HMA Overlay + ¾” OG
# Resilient Modulus Property of the In-Place Mixtures

<table>
<thead>
<tr>
<th>Project</th>
<th>Mr Property at 77°F, ksi</th>
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<tbody>
<tr>
<td></td>
<td>No. of Samples</td>
</tr>
<tr>
<td>2808 US50</td>
<td>14</td>
</tr>
<tr>
<td>2819 US95</td>
<td>8</td>
</tr>
<tr>
<td>2838 SR396</td>
<td>21</td>
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</table>
Mix Design Factors

- **Optimum Moisture Content (216 Moisture Density Curves)**
  4% by Dry Weight of RAP with Lime
  3% by Dry Weight of RAP without Lime

- **Binder Type:** CMS-2S, ERA-25, ERA-75

- **Binder Content:** 3 Levels Based on Appearance
Mix Design Criteria

- Stable over the Range of Binder Content
- Min. Mr at 77°F: 75 ksi at Initial Curing
  150 ksi at Final Curing
- Min. Mr Ratio of 70%
## Mix Designs

<table>
<thead>
<tr>
<th>Binder Type</th>
<th>US50</th>
<th>US95</th>
<th>SR396</th>
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<tbody>
<tr>
<td>Optimum Binder Content</td>
<td>1.0</td>
<td>2.5</td>
<td>1.4</td>
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<tr>
<td>Lime Content</td>
<td>1.5</td>
<td>1.0</td>
<td>1.0</td>
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<tr>
<td>Moisture Content</td>
<td>4.0</td>
<td>4.0</td>
<td>4.0</td>
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</table>
Construction

- Field Adjustments of Binder Content is Allowed
- Measure Properties of Field Mixtures
- Compare Field Mixtures to Mix Designs
Existing Pavement

Recycled Pavement

Crusher-Screening Unit

Mix Paver

Milling Machine

Emulsion Tanker
Windrow

Laydown Machine
Laydown and Compaction
Comparison of mix design and field mixtures at the initial curing stage
Comparison of mix design and field mixtures at the final curing stage

![Comparison of mix design and field mixtures at the final curing stage](image-url)
Performance

- Properties of Cores
- Present Serviceability Index (PSI)
- Rut Depth
### Properties of the Cores Sampled from US50 and US95

<table>
<thead>
<tr>
<th>Project</th>
<th>Sampling Date</th>
<th>Pavement Age</th>
<th>No. of Field Cores</th>
<th>Field Cores Range</th>
<th>Mr at 77°F, ksi</th>
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</thead>
<tbody>
<tr>
<td>US50</td>
<td>8/98</td>
<td>1 year</td>
<td>7</td>
<td>111-285</td>
<td></td>
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<tr>
<td></td>
<td>4/02</td>
<td>4.5 years</td>
<td>8</td>
<td>469-698</td>
<td>205</td>
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<tr>
<td>US95</td>
<td>10/98</td>
<td>1 year</td>
<td>8</td>
<td>200-350</td>
<td>410</td>
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<tr>
<td></td>
<td>8/01</td>
<td>4 years</td>
<td>8</td>
<td>323-720</td>
<td>800</td>
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</table>
PSI performance of the CIR project on US50

Prior to Construction

2808 US 50 EU 38.09 to WP 3.14

EB

WB
Rutting performance of the CIR project on US50

2808 US 50 EU 38.09 to WP 3.14

Prior to Construction
PSI performance of the CIR project on US95

Prior to Construction

2819 US 95 NY 6.92 to 14.37

0.00 1.00 2.00 3.00 4.00 5.00

PSI

Year


NB

SB
Rutting performance of the CIR project on US95

2819 US 95 NY 6.92 to 14.37

Prior to Construction

Year


RD (in)
Conclusions and Recommendations

• CIR is Effective for Low-Medium Traffic Roads

• More Flexible Base to Reduce Reflective Cracking

• Lime Improved Early Stability and Resistance to Moisture Damage
Conclusions and Recommendations

- FWD-Based Layer Coefficient = 0.26
- Continue to use CIR on Low-Medium Volume Roads
- Each Project Should be Designed
Questions