Cold Recycling within ADOT
Lessons Learned and Future Implementation

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Brief History of CIR in AZ (ADOT)

- In use since 1980’s
  - Limited to low volume/rural highways
  - 10 ADOT projects since 2004

![Bar Chart showing CIR in Square Yards by Bid Year]

- 1.5 Million SQYDs
# Past CIR Projects (ADOT)

<table>
<thead>
<tr>
<th>Year</th>
<th>Route (BMP)</th>
<th>Square Yards of CIR</th>
<th>Notes</th>
<th>AADT</th>
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</thead>
<tbody>
<tr>
<td>2004</td>
<td>SR 98 (348.4)</td>
<td>271,018</td>
<td>2% Trucks, Excessive Crack Seal</td>
<td>2555</td>
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<tr>
<td>2004</td>
<td>US 160 (416)</td>
<td>157,095</td>
<td>7% Trucks, Chip Seal, crack sealant</td>
<td>3500</td>
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<td>2005</td>
<td>I-10 FR (267.3)</td>
<td>7,368</td>
<td>Chip Seal, crack sealant</td>
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<td>2006</td>
<td>SR 61 (352.9)</td>
<td>134,146</td>
<td>12% Trucks, Double Chip</td>
<td>2650</td>
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<td>2006</td>
<td>US 60 (49.6)</td>
<td>272,238</td>
<td>46% Trucks, Chip Seal, crack sealant</td>
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<tr>
<td>2009</td>
<td>US 160 (402)</td>
<td>279,705</td>
<td>6% Trucks, Double Chip, crack sealant</td>
<td>2376</td>
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<td>2010</td>
<td>RT 66 (Flag)</td>
<td>28,686</td>
<td></td>
<td></td>
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<tr>
<td>2010</td>
<td>Goodyear</td>
<td>26,900</td>
<td></td>
<td></td>
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<td>2012</td>
<td>SR 77 (395)</td>
<td>200,000</td>
<td>13% Trucks, Chip Seal</td>
<td>1205</td>
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<td>2014</td>
<td>US 89 (510)</td>
<td>151,381</td>
<td>12% Trucks, Double Chip, Crack sealant</td>
<td>4150</td>
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US 89 CIR Failure
US 89 – Gray Spot Wash to North Red Hill
Project Overview

• MP 510.00 – 517.43
• Cold in-Place Recycling (CIR) with AC Overlay
  – Address Pavement Distress (cracking / rutting)
  – Cost Savings (compared to mill and overlay)
  – Increase Structural Capacity
• CIR Operations began June 3rd
• CIR began to fail June 19th
• Removal of CIR material, and shoulder build up operations began shortly thereafter.
• Placed an increased thickness of AC
Progression

- Minor Raveling – Appearance of a Dry Mix – Isolated to a few hundred feet during initial production
- Cold mornings / difficulty getting the emulsion to temperature
- Bleeding – Began as ambient temperatures increased.
- Isolated Shoving – Corrugations began to appear as traffic (stop-and-go) increased – Isolated to areas consisting of material with uncoated and rounded aggregate
- Complete Instability – 4 to 6-inch corrugations “wakes” formed throughout project
- Coarse aggregate was expelled through the leeward side of the wake
- Areas with angular aggregate were last to lose stability
Investigation - Moisture Content

- Existing Pavement 0.6% (prior to June 22nd)
- CIR - Good 1.7%
- CIR - Distressed 2.4% (Average)
  - Moderate Distress 2.1%
  - Severe Distress 2.5%
  - Extreme Distress 2.7%
Investigation - Binder Content

• Numerous Maintenance Activities
  – Not well documented
• Presence of Chip Seal / Double Chip Seal
  • Existing Pavement 6.02%
  • CIR - Good 6.66%
  • CIR - Distressed 7.22% (Average)
    – Moderate Distress 7.12%
    – Severe Distress 7.12%
    – Extreme Distress 7.46%
  • Previous CIR projects measured to be upwards of 9% asphalt content.
Rounded / Smooth Aggregate

- Observed at surface in existing Chip Seal
- Uncoated aggregate observed in paver screed
Causes for CIR Failure

• Primary
  – Excessively warm Ambient / Pavement Temperature
    • Record daily high temperatures during CIR operations

• Secondary
Ambient Temperature (Bitter Springs)

Above 5,000 ft elevation

High Temp

Low Temp

Temperature (°F)
Causes for CIR Failure

• Primary
  – Excessively warm Ambient / Pavement Temperature
    • Record daily high temperatures during CIR operations
  – Type of Emulsion (HFE-300P)
    • Up to 7.5% solvent content (FHWA)
HFE-300P

- Softest Binder Rating (cold climate binder)
  - Solvent (diesel) is added to soften binder
  - High penetration (30mm) allows for improved coating of aggregate
- Requires 2 hours to break
- Must cure (sufficient volatilization of solvent)
- Effectiveness for cold recycling is limited to low volume rural roads with moderate temperatures
Causes for CIR Failure

• Primary
  – Excessively warm Ambient / Pavement Temperature
    • Record daily high temperatures during CIR operations
  – Type of Emulsion (HFE-300P)
    • Up to 7.5% solvent content (FHWA)
  – Traffic
    • Moderate amount of heavy truck traffic
    • Increased holiday/recreational traffic
Traffic

• Increased Traffic prior to Independence Day.
  – RVs
  – Boats
  – Trailers

• Slowing, stop-and-go traffic through project
  – More prevalent once failures required alteration of traffic control
Causes for CIR Failure

• Secondary
  – Excessive Emulsion / Moisture Content
  – Solvent /Binder Content of Existing Pavement
  – Rounded / Smooth Aggregate
Review of Existing ADOT Specifications for Cold Recycling
Material Requirements (408COREC)

• **Recycling Agent** (asphalt emulsion)
  – HFE-300P
    - Soft binder to assist in coating (cold climate emulsion)
    - Up to 7% solvent (for coating)

• **Recycling Additive**
  – No mineral admixture or corrective aggregate

• **Mix Design**
  – Not required (informal)
    - Material sampled from shoulder in two locations
    - Marshall Stability and Flow, Bulk Density
Material Requirements (REV408COREC)

- **Recycling Agent** (asphalt emulsion)
  - Solventless (engineered emulsion)
    - Maximum of 1% solvent

- **Recycling Additive**
  - Lime or Portland Cement
    - Minimum of 30% solids when added as slurry

- **Mix Design**
  - ARRA CR201
    - Comprehensive sampling requirements
    - Medium and Coarse Gradation, multiple designs
    - Volumetrics based on 30 gyrations; 8-15% air voids
    - Indirect Tensile Strength, TSR, Hamburg, 98%
    - LTPPBind, PG, Raveling Test, Fracture Energy
    - High temperature validation (> 85 deg. F)

**Colorado DOT**

- Distress
- Rutting
- Fatigue
- Transverse

2 in. overlay on CIR vs.
4 in HMA:
Savings of $3/sq.yd.
Construction Requirements (408COREC)

• Top Size
  – Process RAP to 100% passing 1-1/4” sieve

• Moisture Content
  – Add approximately 1.5% mixing water
  – Maximum of 3.0% moisture in CIR material prior to addition of an emulsified recycling agent

• Recycling Agent - Add an amount of recycling agent determined by laboratory testing.
  – No definition of required laboratory testing.
  – +/- 0.3% allowance from mix design target during production.

• Temperature Requirements
  – Ambient / Pavement Temperature at least 65°F and rising
Construction Requirements (REV408COREC)

- **Top Size** - 1-1/4” or 1” based on mat thickness
- **Moisture Content** – based on existing conditions and mix design
- **Recycling Agent Content** – Mix Design
  - Production Target within +/- 0.3% of mix design
  - +/- 0.2% allowance from production target
- **Temperature & Seasonal Requirements**
  - Pavement Temperature: 65°F and rising, 130°F max.
  - Ambient Temperature: above 60°F, 95°F max.
  - Minimum overnight Low of 35°F following placement
  - Seasonal exclusions based on project elevation
Construction Requirements (408COREC)

• **Compaction**
  – Commence when the emulsion begins to break or after 2 hours
  – Initial Compaction with pneumatic tired rollers
    • 30 ton pneumatic rollers operating in tandem
    • Minimum of 9 coverages and having “walked-out” the mat
  – Final Compaction with steel wheel rollers
    • Minimum of two coverages with a 12 ton roller

• **Return to Traffic**
  – 2-hour waiting period

• **Placement of Surfacing**
  – Maximum of 1.5% moisture in cold recycled material
Construction Requirements (REV408COREC)

• Compaction
  
  **Cold In-Place Recycled Asphalt Field Shear Vane Test**

  **Determining In-place Flow of Cold In-place Recycled (CIR) Asphalt using the Marshall Hammer**
  Appendix G

• Return to Traffic
  – Shear vane / Marshall hammer

• Secondary Compaction
  – Ambient temperature of at least 80°F
Construction Requirements (REV408COREC)

- Fog Seal
- Equipment Calibration
- Haul Trucks
- Mechanical Spreader
- Slurry Mixing/Storage
- Paver
- Metering and Proportioning
- Just-in-time Training
- Cold Recycling Operations Plan
- Cold Recycling
- Quality Control
- Maintenance
- Addition
- CCPR
- Test Strip
- Surface Preparation
- Water Truck
- MTV
- CCPR
Quality Control (408COREC)

- None
  - No quality control required by 408COREC
  - Adjustments made purely on visual assumptions

“Cold in-Place Recycling is a pure artform.”
Quality Control (REV408COREC)

- Quantities / addition rates
  - Mineral Admixture / Slurry Water
  - RAP
  - Recycling Agent
  - Mixing Water
- Maximum aggregate size @ 1,000 ft intervals
- Field compacted specimens @ 500 ton intervals
  - Includes moisture content determination
- Monitoring compaction with a thin lift nuclear density gauge
  - Compare wet density to field compacted specimens
  - Compare dry density to Gmm in mix design
Acceptance (408COREC)

• Visual Inspection
  – Material has been “walked-out” with no roller marks

• Smoothness
  – ¼” with a 10’ straightedge

• Moisture Content
  – 1-1/2% or less prior to placement of surfacing course
Acceptance (REV408COREC)

- Emulsion Content
  - Within +/- 0.3% of production target based on volume of recycled material

- Compaction
  - Minimum core density of 96% relative compaction when compared to dry density of field compacted specimens.

- Moisture Content
  - 2% or less, or 10 consecutive days without rain
  - No more than 0.5% greater than moisture content prior to recycling

- Surface Requirements
  - 3/8” with a 10’ straightedge
COREC, as it existed previously, was a method specification that specified very few method requirements.
Cold Recycling by Neighboring DOTs

- UDOT, CDOT, NMDOT, NDOT
  - Wide use from rural highways to interstates
  - Up to 10,000 ft + elevation
- CDOT
  - Interstates, mining routes, up to 2800 heavy trucks/day
  - 10 to 20 year design life
- NMDOT
  - I-40, I-10
- UDOT
  - I-15 with typically a 2-3 inch overlay.

Millions of square yards of recycled material each year
Far Reaching Effort

- ARRA – Asphalt Recycling and Reclaiming Association
  - BARM – Basic Asphalt Recycling Manual
  - CR101, CR102, CR201, CR301
- Rocky Mountain Asphalt User/Produce Group
- State / Local DOTs
  - Colorado, Utah, New Mexico, California, Nevada, Coconino County, City of Mesa
- Local Industry / Experts
  - CIR subcontractors, Emulsion Suppliers, Materials Testing Firms, Equipment Manufacturers, Association of General Contractors
- ADOT Personnel
Thank You

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