Cold Recycling:
State of the Practice

Full Depth Reclamation with Asphalt Binders

January 29, 2018
Lubbock, Texas

Stephen A. Cross, PhD, PE
ARRA Technical Director
Professor, Oklahoma State University
The Need Everywhere

Dwindling Budgets +

Dwindling Resources +

Demand for Sustainable Technologies +

Demand by Public for Safe, Quality Pavements =

Need for Alternative Methods
In-Place Pavement Recycling Satisfies the Needs

- Conserves Energy and Natural Resources
- Reduces Construction Truck Traffic
- Improves Mix Characteristics - Some of Our Best Aggregates are In-place
- Cracking Eliminated/Reduced
- May Be Performed Under Traffic
- Saves Construction Time and Reduces User Delays
- Cost Effective - 25% to 50% Cost Savings Over Traditional Methods
Recycle AC to:

- Stable Base
- Within 1” of less Supportive Material
Full Depth Reclamation

Improves existing materials in-place to provide greater structural support and reduction of imported material.
Types of FDR

- **Pulverization**
- **Mechanical Stabilization**
  - Corrective Aggregate
  - RAP
- **Bituminous Stabilization**
  - Emulsified Asphalt
  - Foamed Asphalt
- **Chemical Stabilization**
  - Cement/ CKD
  - Lime/LKD
  - Type C Fly Ash
  - Calcium Chloride
Keys to a Successful In-place Recycling Project?

► Proper Site Selection – Right Method, Right Road, Right Time
► Good Communication and Education
► Good Specifications
Joint Venture of

- ARRA
- AEMA
- ISSA
Treatment Toolbox

► Which Treatment is Best for my Road?
  ▪ Explore by Pavement Criteria
  ▪ Explore by Pavement Photos
► Treatment Resource Center
► Find a Contractor/Supplier
Treatment Toolbox: Which treatment is right for my road? **Pavement Condition**

### Pavement Condition

- B (PCI 70.84)

### Primary Distress

- Oxidation and Raveling - Low (≥ 25% to < 50% Agg L)

### Road Type

- Urban: Major Collect

### Surface Type

- Dense Grade HMA

### Other Factors to Consider

- FOG SEAL
- Rejuvenating Fog Seal
- Slurry Seal
- Micro Surfacing
- Cape Seal
- Ultra Thin Lift HMA
- Chip Seal
- Crack Seal
- Scrub Seal
- Tack Coat
- Prime Coat
- Cold Planing & Micro Milling
- Hot In-Place Recycling
- Cold In-Place Recycling
- Cold Central Plant Recycling
- Full Depth Reclamation
- Base Stabilization
- Soil Stabilization & Soil Modification
Which treatment is right for my road? **Photo Selector**
Photo Selector

**PAVEMENT CONDITION**

(PCI 40-54)

**PRIMARY DISTRESS:**
FATIGUE CRACKING - HIGH

**POSSIBLE SOLUTIONS:**
Consider treatments that address this pavement's primary distress:

FULL DEPTH RECLAMATION
Treatment Toolbox

► Which Treatment is Best for my Road?
- Explore by Pavement Criteria
- Explore by Pavement Photos

► Treatment Resource Center

► Find a Contractor/Supplier
The PPRA Treatment Resource Center is an index of common treatments under various progressive pavement management disciplines. For specific questions contact a [contractor or supplier](#) in your region.

<table>
<thead>
<tr>
<th>Surface Treatments</th>
<th>Pre-Treatments</th>
<th>Recycling &amp; Reclamation</th>
<th>Base Treatments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fog Seal</td>
<td>Tack Coat</td>
<td>Cold Planing &amp; Micro Milling</td>
<td>Base Stabilization</td>
</tr>
<tr>
<td>Rejuvenating Fog Seal</td>
<td>Prime Coat</td>
<td>Hot In-Place Recycling</td>
<td>Soil Stabilization &amp; Soil Modification</td>
</tr>
<tr>
<td>Slurry Seal</td>
<td></td>
<td>Cold In-Place Recycling</td>
<td></td>
</tr>
<tr>
<td>Micro Surfacing</td>
<td></td>
<td>Cold Central Plant Recycling</td>
<td></td>
</tr>
<tr>
<td>Ultra Thin Lift HMA</td>
<td></td>
<td>Full Depth Reclamation</td>
<td></td>
</tr>
<tr>
<td>Cape Seal</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chip Seal</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Crack Seal</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Scrub Seal</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
FOR PAVEMENT CONDITION C D F (PCI of 60 or less)

A cost-effective, long-lasting greener alternative to deep rehabilitation or removal and replacement techniques. Full Depth Reclamation (FDR) is an engineered rehabilitation technique in which the full thickness of the asphalt pavement and a predetermined portion of the underlying materials (base, subbase and/or subgrade) is uniformly pulverized and blended to provide an upgraded, homogeneous material. The reclaimed materials may be improved and strengthened by using Mechanical, Chemical or Bituminous stabilization. FDR isn’t only for roads in poor condition, it is also a viable design process for increasing the structural capacity of a pavement in good condition.

- 40 to 80% less expensive than alternative reconstruction techniques
- Importing and exporting of materials can be reduced by 90%
- Reuses up to 100% of existing materials
- Same day return to light traffic
- Up to 25 years of life extension. The limiting factor for service life of FDR treated pavements is typically the service life of the surface course and not the FDR mixture itself.
- Structural Layer (a) Coefficients of FDR mixtures depends on the stabilizing agent used and vary from 0.14 for pulverization and mechanical stabilization to 0.15-0.25 for cementitious stabilization to 0.20-0.30 for bituminous stabilization.

Issues Addressed
- All forms of cracking and rutting
- Reduced ride quality due to pavement distress
- Loss of surface integrity due to raveling, potholes and bleeding
- Excessive shoulder drop off
- Inadequate structural capacity
- Subgrade instability

Attributes
- Eliminates all existing surface distresses
- Stabilization turns a deficient pavement structure into a new homogeneous section with increased structural capacity
- Reduces impact on underground utilities and structures
- Conserves non-renewable resources and reduces trucking
- Deteriorated subgrade or base can be reshaped to restore surface profile and drainage
- Cost savings compared to other rehabilitation methods
- Reduces community impacts, traffic disruptions and user inconvenience
- Reduces contractor change orders resulting from unstable soil/base conditions
TRC – FDR Expectations

**Expectations**

FDR is an alternative to deep rehabilitation and reconstruction techniques. It can treat all manner of distresses in the pavement structure except drainage issues and deep subgrade instability (greater than 2 feet below the existing surface). Deep subgrade issues can be treated with FDR in combination with soil stabilization. The service life of a FDR pavement is dependent on a good structural design and the adequacy of the selected treatment to mitigate the existing distress. The limiting factor of a well-designed and constructed FDR pavement is often the life expectancy of the wearing surface and not the FDR layer. In optimum application situations, many agencies see their FDR treatments lasting 25 plus years.

<table>
<thead>
<tr>
<th></th>
<th>Optimum</th>
<th>Moderate</th>
<th>Reactive</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Type of Distress</strong></td>
<td>Any distress in the treated layers</td>
<td>Minor drainage and/or some subgrade instability</td>
<td>Drainage issues and subgrade instability</td>
</tr>
<tr>
<td><strong>Depth of Distress</strong></td>
<td>Extends no deeper than treated layers</td>
<td>Below FDR treatment</td>
<td>Below FDR treatment</td>
</tr>
<tr>
<td><strong>Life Extension</strong></td>
<td>25+ years</td>
<td>15-25 years</td>
<td>5-15 years</td>
</tr>
</tbody>
</table>

**EXAMPLES OF ROADS THAT HAVE BEEN TREATED WITH FULL DEPTH RECLAMATION OVER VARIOUS STAGES IN SERVICE LIFE:**

- Georgia FDR Before
- Georgia FDR After
- Clipper, Rd South Carolina Before FDR
- Clipper, Rd South Carolina During FDR
**TRC – FDR Equipment**

### Equipment

**Reclaimer**
- One or more self-propelled reclaimers to pulverize and mix the asphalt pavement and underlying materials in a single pass and to mix stabilizing agent and additives into the pulverized materials in a second pass
- The reclaimer should have controls to adjust depth of pulverization
- The reclaimed should have a computerized liquid addition system, a meter to record the flow and total amount of liquid added, and a positive interlocking system linked to the speed of the reclaimer to adjust the liquid addition rate

**Calibrated Bulk Spreaders/Distributors**
- Required for application of dry stabilizing agents and additives
- They should be non-pressurized mechanical vane-feed, cyclone or screw type capable of providing a consistent, accurate and uniform distribution of material while keeping dust to a minimum
- Corrective aggregate or RAP may be placed by a mechanical spreader, conventional paver or by tailgating

**Tanker Trucks**
- Bituminous stabilizing agents (emulsified asphalt and asphalt for foaming) are delivered to the project site in tanker trucks and fed into the reclaimer using the reclaimer’s on-board liquid addition system

**Motor Grader**
- For pre-shaping, aeration, spreading and final shaping of the reclaimed material
TRC - Inspection

- Mix Design
- Surface Preparation
- Acceptable Weather
- Traffic Control
- Quality Equipment
- Quality Workmanship
- Application Rates
- Additional Resources
TRC – Testing, Troubleshooting & Acceptance

► Testing Protocol
  ■ Tables Describing:
  ▪ Pre-Construction Testing
  ▪ Construction Testing
  ▪ Post-Construction Testing

► Troubleshooting
  ■ Construction
  ■ Post-Construction

► Acceptance
Treatment Resource Center

- Cold Planing
- Hot In-place Recycling
- Cold Recycling
- Full Depth Reclamation
- Detailed Project Analysis
- Mix Design
- Construction
- Project Specifications and Inspection

FHWA –HIF-14-001
Recycling Tab

► Why Recycling & Reclaiming
  ■ Lower Costs
  ■ Engineering Benefits
  ■ Environmental Benefits
  ■ Time Savings

► Structural Comparison
  ■ About
  ■ Calculator

► ARRA Publications
► About ARRA
Network Optimization

► Optimize Your Network
- Life Cycle Cost
- Equivalent Annualized Cost
- Remaining Service Life
- Cost Benefit Value
ARRA Best Practice Guidelines

► 100 Series Construction Best Practice Guidelines
  ■ Suggested Specification Language

► 200 Series Project Sampling & Mix Design Guidelines

► 300 Series QC Guidelines
  ■ Recommended Quality Control Checks and Remediation Actions

► All Provide User Notes for More Information
New AASHTO Provisional Standards
(Based on ARRA CR201)

Standard Practice for Emulsified Asphalt Content of Cold Recycled Mixture Designs

AASHTO Designation: PP 86-17
Technical Section: 2a, Emulsified Asphalts
Release: Group 3 (August 2017)

Standard Specification for Materials for Cold Recycled Mixtures with Emulsified Asphalt

AASHTO Designation: MP 31-17
Technical Section: 2a, Emulsified Asphalts
Release: Group 3 (August 2017)
Submitted Draft AASHTO Provisional Standards

► Standard Practice for Emulsified Asphalt Content of Full-Depth Reclamation Mixture Design
  ■ AASHTO Designation: PP xxx-xx, Technical Section: 2a

► Standard Specification for Materials for Full-Depth Reclamation Mixture with Emulsified Asphalt
  ■ AASHTO Designation: MP xxx-xx, Technical Section: 2a

► Based on ARRA FDR 201
AASHTO Guide Specifications Under Development

► AASHTO GUIDE SPECIFICATION for COLD IN-PLACE RECYCLING
  ▪ Based on ARRA CR101 & ARRA CR301

► AASHTO GUIDE SPECIFICATION for COLD CENTRAL PLANT RECYCLING
  ▪ Based on ARRA CR102 & ARRA CR301

► AASHTO GUIDE SPECIFICATION for Full Depth Reclamation Using Bituminous Stabilizing Agents
  ▪ Based on ARRA FDR101 & ARRA CR301
Overview of Project Selection
Guidelines for Cold In-place and Cold Central Plant Pavement Recycling

This Technical Brief provides project selection guidelines for the cold recycling techniques of cold in-place and cold central plant recycling. The Tech Brief intends to aid the user in properly selecting candidate projects for using cold pavement recycling. Significant improvements in cold recycling technologies have been made since the 2000s, including improvements in engineering, construction equipment, and test methods, together with improved mix designs, resulting in improved reliability of performance of the final product.

Introduction

Various in-place recycling techniques have been used to rehabilitate and maintain pavements in the United States since the 1930s. Two events of the 1970s rekindled interest in asphalt recycling: the petroleum crisis and the development of large-scale cold planning equipment with easily adjustable milling teeth.

In recent years, the economics and supply of petroleum and high quality natural aggregates have increased the need for cost-effective alternatives to virgin paving materials. Two in-place recycling alternatives include cold in-place recycling (CIR) and cold central plant recycling (CCPR). These methods provide owner agencies with cost effective and sustainable methods to repair their aging asphalt pavements. When applying the right treatment to the right road at the right time, and when properly designed, specified and constructed, these methods can result in cost savings of 30 to 50 percent compared to conventional asphalt operations, thus allowing for more miles of improved roadways from the associated cost savings. In addition, CIR and CCPR have been shown to accelerate project delivery and mitigate construction traffic congestion while including improvements in the overall sustainability of operations.

In spite of economically and environmentally effective technologies being available for decades, many owner agencies
FHWA Pocket Guides

► Pavement Preservation Application Checklist Series

11 Hot In-Place
   Asphalt Recycling
   Application Checklist

12 Cold In-Place
   Asphalt Recycling
   Application Checklist

Full Depth Reclamation Construction Checklist
Transportation Curriculum Coordination Council (TC3)

- Web Based Inspector Training Courses on:
  - HIR – No. 2590
  - CIR – No. 2509
  - FDR – No. 2539
- Hosted by AASHTO
- Free at Checkout
- Consist of Modules Covering
  - Introduction
  - Pre-Production Activities
  - Full Production
  - Post Construction Activities
Full Depth Reclamation (FDR)
Module 1: Introduction

The presentation is available as an attachment from the paperclip icon in the bottom right-hand part of the screen.
Where to find?
www.ARRRA.org
www.ARRAn.org

RESOURCES

- Guidelines
- Training Courses
- Presentations & Papers
- Pocket Guides
- Archived Newsletters
Thank You

Stephen A Cross, PhD, PE
Technical Director, ARRA
Professor, Oklahoma State University
405-744-7200
steve.cross@okstate.edu