2019 FDR Symposium

Sustainability of FDR
and
ARRA Resources
Greensboro, North Carolina
April 24-25, 2019

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Technical Director
Asphalt Recycling & Reclaiming
Association
Industry Segments

- **Cold Planing**
- **Hot In-Place Recycling**
- **Cold Recycling**
  - CIR & CCPR
- **Full Depth Reclamation**
- **Soil Stabilization**
**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
  - Calcium Chloride
  - Class C Fly Ash
Full Depth Reclamation Construction Sequence

Old Asphalt
 Base
 Sub-base

Existing road

Pulverization to design depth

Pulverized
 Sub-base

Removal of excess material (if necessary) and shaping

Pulverized
 Sub-base

Addition of stabilizing agents, mixing & compacting

Stabilized
 Sub-base

Stabilized
 Sub-base

New Surfacing

Final surface course
FDR must be surfaced

FDR layers can be surfaced with any type of pavement material.

- HMA
- Seal Coats
- PCCP

Typical AASHTO Structural Layer Coefficient 0.15 – 0.25.

Not best way to design FDR with cement
Pavement Preservation

The diagram illustrates the relationship between the age of pavement and its condition index. It shows how Pavement Preservation (PP) and Reactive Maintenance (RM) can be applied at different stages of pavement life to maintain its condition.

- **Excellent** to **Fair** drop in quality occurs at 75% of life.
- **Fair** to **Poor** drop in quality occurs at 12% of life.
- **Poor** to **Failed** drop in quality occurs at the end of pavement life.

The costs are indicated:
- $2.00 for PP at 40% drop in quality (PP Here).
- $4.00 for RM based on PCI at 75% of life (RM Here).
- Will Cost $12.00 to $16.00 for Rehabilitation Here at 12% of life.

PP = Pavement Preservation, RM = Reactive Maintenance.
Sustainability

20 ton load of cement at 5% treats 400 tons material

1-way haul

- 50 - 67 truckloads
- 27 - 31 truckloads
- 19 - 20 truckloads
- 19 - 20 truckloads
FDR vs. New Base

1 mile, 24-foot wide, 6-inch base (PCA)

- Number of trucks needed: 12 vs. 180
- New roadway material (tons): 300 vs. 4,500
- Material landfill (cubic yards): 0 vs. 2,700
- Diesel fuel consumed (gallons): 500 vs. 3,000

New Base vs. Full Depth Reclamation
Joint Venture of
- ARRA
- AEMA
- ISSA
Pavement Preservation

► Why Pavement Preservation
► Sustainability Calculator
► ISSA Publications
► About ISSA
Cost & Green Calculator

**Conventional Approach**
- **Treatment:** Full Depth Remove & Replace
- **Unit Cost:** 39.01
- **Life Extension:** 25.0
- **Square Yards:** 14000

**Total Cost:** $546,140
**Equivalent Annualized Cost:** 1.56

**Preservation & Recycling Approach**
- **Treatment:** Full Depth Reclamation + 4” HM
- **Unit Cost:** 28.54
- **Life Extension:** 25.0
- **Square Yards:** 14000

**Total Cost:** $399,560
**Equivalent Annualized Cost:** 1.14

By choosing a preservation & recycling approach...

**Cost Savings**
- **$146,580**
- **27% less than full depth remove & replace**

**Environmental Savings**
- **Reduce greenhouse gas emissions by 13%**

That’s the green equivalent of removing 5 passenger vehicles from US roadways for a year!
Recycling Tab

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

► Structural Comparison
  ◼ About
  ◼ Calculator

► ARRA Publications

► About ARRA
Existing Pavement
4” HMA over Subgrade

- **Conventional Approach**
  - Remove Existing Pavement to Subgrade
  - 8” Subgrade Stabilization with 5” HMA overlay

- **Recycle Approach**
  - 8” FDR
  - 3” HMA
Structural Comparison Calculator

Conventional Approach

<table>
<thead>
<tr>
<th>Layer Type</th>
<th>Depth (in)</th>
<th>Coefficient</th>
<th>Cost/SY</th>
<th>SN</th>
</tr>
</thead>
<tbody>
<tr>
<td>HMA 2&quot;</td>
<td>2.0</td>
<td>0.44</td>
<td>9.29</td>
<td>0.88</td>
</tr>
<tr>
<td>HMA 3&quot;</td>
<td>3.0</td>
<td>0.44</td>
<td>13.94</td>
<td>1.32</td>
</tr>
<tr>
<td>Soil Stabilization &amp; Modificatix</td>
<td>8.0</td>
<td>0.12</td>
<td>7.85</td>
<td>0.96</td>
</tr>
<tr>
<td>Remove Existing Asphalt 2&quot;</td>
<td>2.0</td>
<td>0.0</td>
<td>15.00</td>
<td>0.00</td>
</tr>
<tr>
<td>Remove Existing Asphalt 2&quot;</td>
<td>2.0</td>
<td>0.0</td>
<td>15.00</td>
<td>0.00</td>
</tr>
</tbody>
</table>

Overall Structural Number: **3.16**

0 SY x **$34.08** /SY = **$0** total

FDR

Optimized: Recycling First

<table>
<thead>
<tr>
<th>Layer Type</th>
<th>Depth (in)</th>
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<th>Cost/SY</th>
<th>SN</th>
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<tr>
<td>HMA 3&quot;</td>
<td>3.0</td>
<td>0.44</td>
<td>13.94</td>
<td>1.32</td>
</tr>
<tr>
<td>Full Depth Reclamation 8&quot;</td>
<td>8.0</td>
<td>0.22</td>
<td>9.95</td>
<td>1.76</td>
</tr>
</tbody>
</table>

Overall Structural Number: **3.08**

0 SY x **$23.89** /SY = **$0** total

Reconstruction

FDR Saved **$10.19/SY**
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**

<table>
<thead>
<tr>
<th>Pavement Condition</th>
<th>Primary Distress</th>
<th>Road Type</th>
<th>Surface Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>B (PCI 70.84)</td>
<td>Oxidation and Raveling - Low (≥ 25% to &lt; 50% Agg L)</td>
<td>Urban: Major Collect</td>
<td>Dense Grade HMA</td>
</tr>
</tbody>
</table>

- **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**

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A **F** B **D** C **D** E **F**
Which treatment is right for my road? **Photo Selector**
Photo Selector

PAVEMENT CONDITION

D
(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>
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<td>Rejuvenating Fog Seal</td>
<td>Prime Coat</td>
<td>Hot In-Place Recycling</td>
<td>Soil Stabilization &amp; Soil Modification</td>
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<tr>
<td>Slurry Seal</td>
<td></td>
<td>Cold In-Place Recycling</td>
<td></td>
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<td>Cold Central Plant Recycling</td>
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<tr>
<td>Ultra Thin Lift HMA</td>
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<td>Full Depth Reclamation</td>
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</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>
FDR Treatment Resource Center

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>FDR</th>
<th>Optimum</th>
<th>Moderate</th>
<th>Reactive</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type of Distress</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>Depth of Distress</td>
<td>Extends no deeper than treated layers</td>
<td>Below FDR treatment</td>
<td>Below FDR treatment</td>
</tr>
<tr>
<td>Life Extension</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
**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, aerating, 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
Full Depth Reclamation
Chapters 14-17

ASPHALT RECYCLING & RECLAIMING ASSOCIATION
U.S. Department of Transportation Federal Highway Administration

FHWA –HIF-14-001
Optimize Your Network

- Life Cycle Cost
- Equivalent Annualized Cost
- Remaining Service Life
- Cost Benefit Value
Life Cycle Cost Calculator

Save big over the life of your pavement with progressive maintenance

By choosing an optimized treatment strategy...

Optimized Strategy
Total Savings: $29,500,000

Net Present Value: $50.00/5Y
Total Life Cycle Cost: $50.0M
Remaining Service Life

Is your network gaining or losing life each year?

Understanding Remaining Service Life (RSL) is critical to designing a treatment plan that stretches your budget further and reverses the trend of a deteriorating network.

Download the FHWA RSL pub IF-07-006

CRITICAL CONCEPT

A 500-mile network loses 500 mile-years of life annually.

Every year, every mile of your network loses 1 mile-year of life. To avoid losing ground, the roadway owner must design a treatment plan that adds 500 mile-years of life or more!
Remaining Service Life

Total Network Lane-Miles: 1000
Average Lane Width (ft): 15
Total Budget: $5000000
Remaining Budget: $2,920

<table>
<thead>
<tr>
<th>Treatment Type</th>
<th>Category</th>
<th>Life Extension</th>
<th>Lane-Miles* Treated</th>
<th>Lane-Mile-Years</th>
<th>Unit Cost</th>
<th>Total Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rejuvenating Fog Seal</td>
<td>Preservation</td>
<td>3.0</td>
<td>25</td>
<td>75</td>
<td>0.67</td>
<td>$147,400</td>
</tr>
<tr>
<td>Micro Surfacing: Double Lift</td>
<td>Preservation</td>
<td>8.0</td>
<td>34</td>
<td>272</td>
<td>3.92</td>
<td>$1,172,864</td>
</tr>
<tr>
<td>Chip Seal</td>
<td>Preservation</td>
<td>6.0</td>
<td>40</td>
<td>240</td>
<td>2.06</td>
<td>$725,120</td>
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<tr>
<td>Cape Seal</td>
<td>Preservation</td>
<td>10.0</td>
<td>24</td>
<td>240</td>
<td>5.20</td>
<td>$1,098,240</td>
</tr>
<tr>
<td>Minor Mill &amp; Fill</td>
<td>Rehabilitation</td>
<td>11.0</td>
<td>2</td>
<td>22</td>
<td>9.80</td>
<td>$172,480</td>
</tr>
<tr>
<td>Cold Recycling + 1.5&quot; HMA</td>
<td>Rehabilitation</td>
<td>15.0</td>
<td>4</td>
<td>60</td>
<td>13.98</td>
<td>$492,096</td>
</tr>
<tr>
<td>Full Depth Reclamation + 4&quot; HMA</td>
<td>Reconstruction</td>
<td>25</td>
<td>2</td>
<td>50</td>
<td>28.54</td>
<td>$502,304</td>
</tr>
<tr>
<td>Full Depth Remove &amp; Replace</td>
<td>Reconstruction</td>
<td>25.0</td>
<td>2</td>
<td>50</td>
<td>39.01</td>
<td>$686,576</td>
</tr>
</tbody>
</table>

Congratulations

You added 1,009 lane-mile-years of life

9 lane-mile-year net gain
13% of roads addressed
My PPRA Account

Input costs and life extension in your area to make the most of the site & tools

Change aggregate data into costs, life extension, and structural numbers relevant to you. Tools throughout the site automatically re-populate with your data every time you log in.
ARRA Developed Best Practice Guidelines to Complement BARM

- 100 Series - Recommended Construction Guidelines
- 200 Series - Preconstruction Sampling & Mix Design
- 300 Series - Recommended Quality Control Sampling and Testing Guidelines
- 400 Series – Project Selection Guidelines
Education Resources

► Pavement Preservation Application Checklist Series
► Updated HIR & CIR, New FDR
► www.arra.org & www.fhwa.gov
Transportation Curriculum Coordination Council (TC3)

- Web Based Inspector Training
  - Courses on:
    - HIR
    - CIR
    - FDR
- 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.
Thank You

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