Full Depth Reclamation

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About Delaware County

- Highly diverse county
- Large scale rural development in southern half
- Northern half remains largely rural
About Delaware County

- Fastest growing county in Ohio
- 160% population growth between 1990 and 2010
About Delaware County

- Explosive growth since 1990 fueled by opening of I-71 & Polaris Pkwy. interchange in 1991

- Growth created major roadway infrastructure needs in fringe areas of development
Road History

- Many old farm-to-market roads now serving large scale residential and commercial developments
- Inadequate pavement structure to support construction traffic
Road History

- Most county roads were less than 20 feet wide with chip and seal surfaces.
- HMA overlay projects through the early 1990’s were ineffective at maintaining or improving pavement.
  - Reflective cracking
  - Loss of cross slope early in maintenance cycle
Need for Road Improvement

- 1990’s – explosive residential and commercial growth creating huge need for improvement to old farm to market roads

- 1997 – first Delaware County road improved by full depth reclamation
What Is Full Depth Reclamation (FDR)

- Full Depth Reclamation is a pavement rehabilitation technique in which the full flexible pavement section and a predetermined portion of the underlying materials are uniformly crushed, pulverized or blended.
What Is Full Depth Reclamation (FDR)

- Pulverization of pavement and underlying road base to create a uniform, stabilized base course.
What Is Full Depth Reclamation (FDR)

- Chemical additives can increase performance of the stabilized base
  - Asphalt recycling emulsions
  - Pozzolans
    - Cement
    - Fly ash
    - Lime or lime kiln dust
Restore Cross Slope

EXISTING SECTION (BEFORE FDR)

PROPOSED SECTION (AFTER FDR)
Widening with FDR
FDR Process

- Step 1: Pulverization

1st Pass

Working Direction
FDR Process

- Step 2: Mixing of additives
FDR Process

- Step 3: Grading and compaction
FDR Process

- Step 4: Chip seal or fog seal on stabilized base
FDR Process

- Step 5: Placing asphalt surface
Maintenance of Traffic

- Desirable to close road during pulverization and mixing, but can maintain one lane, two-way local or low volume traffic

- Once compaction is complete and base is seal coated, local traffic can be restored

- Typical 5 to 10 day curing period for cement treated base course… keep trucks off!

- Normal one lane, two-way local traffic during asphalt placement
Why Use FDR

- FDR eliminates reflective cracks

<table>
<thead>
<tr>
<th>Full Depth Reclamation</th>
<th>Mill &amp; Fill</th>
<th>Overlay</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Surface Course</strong></td>
<td><strong>1.5&quot; Mill &amp; Fill</strong></td>
<td><strong>1.5&quot; Overlay</strong></td>
</tr>
<tr>
<td>6-10&quot; FDR</td>
<td>HMA</td>
<td>HMA</td>
</tr>
<tr>
<td>Subgrade</td>
<td>Base/Sub-base</td>
<td>Base/Sub-base</td>
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<tr>
<td></td>
<td>Subgrade</td>
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## FDR vs. Base Replacement

### Low to moderate volume road example

<table>
<thead>
<tr>
<th></th>
<th>FDR</th>
<th>Base Replacement</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Total Cost per square yard</strong></td>
<td><strong>$16 to $22</strong></td>
<td><strong>$26 to $34</strong></td>
</tr>
<tr>
<td>Base HMA Overlay</td>
<td>$6 to $10</td>
<td>$8 to $12</td>
</tr>
<tr>
<td></td>
<td><strong>$10 to $12 (3”)</strong></td>
<td><strong>$18 to $22 (6”)</strong></td>
</tr>
<tr>
<td><strong>Time</strong></td>
<td>5-8 days per lane mile</td>
<td>2-3 weeks per lane mile</td>
</tr>
<tr>
<td><strong>Result (Overall SN)</strong></td>
<td><strong>Increased structure 3.45+</strong></td>
<td><strong>Adequate structure 2.94</strong></td>
</tr>
<tr>
<td><strong>Energy Use</strong></td>
<td><strong>Low</strong></td>
<td><strong>High</strong></td>
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FDR: 8” cement treated reclaimed base + 3” HMA surface

Base Replacement: 6” aggregate base + 6” HMA surface
FDR vs. Base Replacement

Less truck traffic = Less damage to haul routes

Energy Use and Materials

<table>
<thead>
<tr>
<th></th>
<th>Full-Depth Reclamation</th>
<th>New Base</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of Trucks Needed</td>
<td>12</td>
<td>180</td>
</tr>
<tr>
<td>New Roadway Material tons (metric tons)</td>
<td>300 (270)</td>
<td>4,500 (4,100)</td>
</tr>
<tr>
<td>Material Landfilled cubic yard (m³)</td>
<td>0</td>
<td>2,700 (2,100)</td>
</tr>
<tr>
<td>Diesel Fuel Consumed gallon (liter)</td>
<td>500 (1,900)</td>
<td>3,000 (11,400)</td>
</tr>
</tbody>
</table>

Based on 1 mile (1.6 km) of 24-foot (7.3-m)-wide 2-lane road, 6-inch (150-mm) base

Courtesy of Portland Cement Association
FDR Design Process

- FDR is an **engineered process**!
- For proper design, you need to know
  - Existing pavement composition
  - Required design structural number
  - Allowable pavement profile rise
FDR Design Process

- Pavement design structural layer coefficient for stabilized base course
  - Depends on existing pavement composition
  - Typical SN layer coefficient of 0.26 to 0.30 for FDR with emulsion
  - Addition of pozzolans (cement, fly ash, lime kiln dust) yields higher SN layer coefficients in the range of 0.30 to 0.45.
South Section Line Road Research Project

- South Section Line Road carries high truck traffic volumes
- Good candidate for reclamation due to thick existing asphalt, but with base failure
South Section Line Road Research Project

- In 2006, Delaware County worked with the Ohio State University and the Ohio Coal Development Office to construct a research project to evaluate reclamation additives.

- 4 miles of road reclaimed using test sections with various FDR additives.

- Project sought a beneficial use of coal fly ash.
South Section Line Road Research Project

- Test sections included the following FDR additives:
  - Portland cement
  - Cement and asphalt emulsion
  - Lime kiln dust and emulsion
  - Fly ash and lime kiln dust
  - Fly ash and lime

- Also a mill and fill only control section
South Section Line Road Research Project

Deflections in South Bound Lane - Delaware Co. Site

Location (miles from start)

Deflection (miles)

After

Before

Figure 4.18 Delaware County – Deflections in South Bound Lane for FWD Testing
South Section Line Road Research Project

Figure 4.20 Delaware County – Resilient Modulus Results from FWD Testing
Conclusions of project:

- FDR sections performing well with minimal surface distress after 5 years.
- Adding cement provides fastest increase in base layer stiffness.
- Fly ash and lime kiln dust also develop high strength but over longer time period.
- FDR process is highly cost effective versus traditional base replacement/reconstruction.
South Section Line Road Research Project

- Final report available on the OSU Coal Combustion Products Program website
Delaware County Experience with FDR

- Over 50% of county maintained roads were reclaimed by FDR between 1997 and 2006

- Now in a pavement preservation mode rather than pavement rehabilitation

- Delaware County has been able to use less expensive preservation treatments on these roads such as microsurfacing and chip sealing instead of additional asphalt to maintain the good condition
Delaware County Experience with FDR

- Excellent performance with addition of pozzolans (typically Portland cement)
- Less performance with addition of asphalt emulsions
- Minor widening to achieve acceptable pavement width through FDR process
  - 2 foot widening commonly done in conjunction with FDR process by edge trenching prior to pulverization
Delaware County Experience with FDR

- FDR provides longer service live for the asphalt wearing surface.

- Pavement deterioration curve is flatter and sharp drop-off is delayed by several years.
Delaware County Experience with FDR

- Pavement preservation must start with good pavement
- FDR can be a critical first step in getting into a pavement preservation mode
Where To Use FDR

- Uncurbed roads with base failure that can tolerate profile rise of 3 to 6 inches
  - Best bang for the buck – no need for removal of existing pavement materials
- Roads with adequate shoulders where minor pavement widening is needed
  - 1 to 4 foot widening is possible
- Roads needing cross slope correction
Where **Not To Use FDR**

- Thin existing pavements without at least 8 inches of existing asphalt and granular pavement
  - Process requires granular material to produce acceptable composition of the stabilized base course
  - If existing pavement is only a little bit too thin, course aggregate can be spread before the pulverization pass and be incorporated into the RSB
Conclusions

- Excellent system for improving road base at a fraction of the cost of reconstruction

- Though it is possible to field engineer the process, doing borings and pavement design in advance is key to optimizing the process

- A special thanks to OSU for their work on the South Section Line Road fly ash project
Questions

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www.DelawareCountyEngineer.org