How One City is using FDR to Address its Pavement Problems

April 25, 2019

2019 Full-Depth Reclamation Symposium
Presentation Overview

- Existing Street Network, Funding Trends, and Existing Pavement Condition in Rocky Mount.
- What is FDR?
- The Rocky Mount experience.
Street Network, Then & Now

- City maintains approximately 280 mile network of paved and unpaved streets.
- NCDOT maintains 121 miles of streets within Rocky Mount.
- Based on 2007 Pavement Condition Survey, average PCI for the street network is 81.
- Approximately 35 miles of streets with PCI < 60 (low fair, approaching poor).
Street Network, Then & Now

- Based on preliminary budget estimates, streets with PCI < 60 comprise over 78% of the repair costs for the existing network.

- Although draft of 2018 Pavement Condition Survey reflect an average network PCI of 71, a difference in methodologies is likely to account for a majority of the differences.

- Sections of roadways treated with FDR since FY 2009 are holding up very well.
Funding Trends

- Steadily declining Powell Bill reimbursements and escalating costs have severely constrained major maintenance activities such as resurfacing.

Source: NCDOT Program Development Branch (Benson and Al-Ghandour – 2014)
Funding Trends

- Steadily declining Powell Bill reimbursements and escalating costs have severely constrained major maintenance activities such as resurfacing.
AC Binder Cost Over Time

August 2008 - $793.08 per ton
Less than $400 per ton from Feb 2016 to Jan 2018

Source: NCDOT Pavement Construction Section
Pavement Management

- The City conducts a pavement condition survey on 10 year cycles and uses the data in a Pavement Management Program to prioritize maintenance needs and determine the best strategy for use of limited maintenance funds.

- Have historically relied on more of a worst-first strategy, but due to shrinking revenues the city is seeking to transition to an approach that optimizes allocation of resources based on life cycle cost.

- Alternative strategies will be needed to allocate limited funding available to meet pavement preservation and rehabilitation needs.
State of the Network in 2007

- Average network PCI value = 81
- “Satisfactory” overall condition
- Approximate pavement value = $200M
State of the Network in 2007, Overall

- ~90% of the network in fair or better condition.
Examples – Good (86-100)
Examples – Fair (56-70)
Examples – Poor (41-55)
Examples – Serious / Failed (0-25)
Preventative Maintenance Concept

Pavement Age in Years

4  8  12  16

Pavement Condition

Excellent
Good
Fair
Poor
Very Poor

75% Time

40% Quality Drop

Each $1 in Repair Cost here...

Will Cost $4 - $10 if Delayed to Here

40% Quality Drop

18% Time
M&R Needs/Backlog

![Graph showing M&R Activities percentage of Centerline Miles and Cost.]

M&R Activities:
- Do Nothing
- Preventive
- 1" Resurfacing
- Mill & Resurface
- Reconstruction

Percentage of Centerline Miles and Cost.
Investment Scenarios (2007)

Area-Weighted Network PCI

Year

- No M&R
- Current Funding, $1.18mil/yr
- Maintain Performance, $3.9mil/yr
- Clear Backlog, $4.6mil/yr
Potential Strategies

- Re-evaluate pavement design guidelines to increase anticipated service life.
- Account for cost of binder in contract.
- Explore more cost effective approaches to preserve and rehabilitate pavements.
FDR – A NEW DEAL IN ROCKY MOUNT
What is FDR?

- Pavement rehabilitation technique in which the full flexible pavement section and a predetermined portion of the underlying materials are uniformly crushed, pulverized, and blended into a homogenized stabilized base course. Further stabilization may be obtained through the use of additives.
FDR versus CIR and HIR

- Primary difference between FDR and cold in-place recycling or hot in-place recycling is penetration into the material beneath the flexible pavement section.
- FDR is less susceptible to reflective cracking due to an existing base failure.
- FDR enhances the overall pavement structure due to a strengthened base.
What is FDR?
## Typical Additives used with FDR

<table>
<thead>
<tr>
<th>Type and Typical Trial Percents of Stabilizer</th>
<th>Characteristics of Reclaimed Pavement Materials</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hydrated Lime or Quicklime 2 to 6% by weight (1)</td>
<td>Reclaimed asphalt pavement (RAP) having some amount of silty clay soil from sub-grade with a plasticity index greater than 10.</td>
</tr>
<tr>
<td>Class C Fly Ash (2,3) (8 to 14% by weight)</td>
<td>Materials consisting of 100% RAP or blends of RAP and underlying granular base or soil. The soil fraction can have plasticity or be similar to soils acceptable for lime treatment.</td>
</tr>
<tr>
<td>Portland Cement (3) (3 to 6% by weight)</td>
<td>Materials consisting of 100% RAP or blends of RAP and underlying granular base or non-plastic or low plasticity soils. There should be sufficient fines to produce an acceptable aggregate matrix for the cement treated base (CTB) produced (not less than 45% passing the 4.75 mm or No. 4 sieve preferred).</td>
</tr>
<tr>
<td>Emulsified or Foamed Asphalt (4) (1 to 3% by weight) (5)</td>
<td>Materials consisting of 100% RAP or blends or RAP and underlying granular base or non-plastic or low plasticity soils. The maximum percent passing the 75 μm (No. 200) sieve should be less than 25%, the plasticity index less than 6 or the sand equivalent 30 or greater, or the product of multiplying the P.I. and the percent passing the 75 μm being less than 72.</td>
</tr>
<tr>
<td>Calcium Chloride (1% by weight)</td>
<td>Materials consisting of a blend of RAP and non-plastic base soils with 8 to 12% minus 75 micron material. Small amounts of clay 3 to 5% are also beneficial.</td>
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</tbody>
</table>
Process for Cement Modified Full Depth Reclamation
Step 1: Initial Pulverization
Step 2: Initial Grading
Step 3: Adding Cement
Step 4: Final Grading, Compaction, & Curing
Step 6: Paving
Selection of Street Sections for FDR Pilot Project
Initial Screening

- FDR considered for one location requiring reconstruction and locations with high percentage of patching
- Streets proposed for resurfacing were evaluated to determine the quantities of patching required
- Cost of patching was compared to the cost of FDR for the entire street section based on a FDR cost of $7/SY.
- FDR appeared to be cost effective when full depth patching exceeded 25% of the street surface area.
- 10 street sections with patching needs in excess of 25% were selected for further evaluation based on the amount of patching required.
Evaluation of Selected Streets

- GeoTechnologies, Inc. was retained to evaluate the pavement sections for the candidate locations and provide recommendations for pavement design and FDR formulation.

- Existing pavement/base course thicknesses and CBR values were highly variable but all candidate streets were determined to be viable for cement modified FDR.

- Structural coefficient of 0.2 was used for the reclaimed base material in the pavement design. Subgrade CBR values ranged between 3 and 30.
Evaluation of Selected Streets

- Recommended cement content for the reclaimed base course ranged between 3 and 4.5% by weight. Higher contents typically used with STBC.

- Recommended pavement thickness (S9.5B) ranged between 1.5” and 3”.

- 3” surface course was utilized on FDR section of 5,023 ft minor arterial street that included widening to add a center turn lane in front of an elementary school. Work was completed in less than 2 weeks.
Other Considerations

- Thickness and quality of existing asphalt, base course and subgrade will impact the quality of the reclaimed base.
- Excessive volumes of high plasticity soils in the reclaimed base will reduce strength and increase risk of moisture infiltration. May need to consider combination of additives.
- Small amounts of soil may be incorporated into the reclaimed base course provided they have very low plasticity.
Other Considerations

- Reclaimed base must be thoroughly blended and asphalt needs to be broken into pieces no more than 3” in diameter. Multiple passes may be required.

- Compaction and grading of stabilized base needs to be completed within 4 hours of addition of cement. Moisture content needs to be within 2% of optimum.

- Compaction of stabilized base should be 98% of Standard Proctor Maximum Dry Density.

- Ideally, paving should follow within 24 hours unless material can be kept wet or seal coated to trap moisture and facilitate curing.
Other Considerations

- Depth of utilities (including storm drains)
- Age and type of utility pipe.
  - Vibration off milling operations could crack pipes or failed joints
- Excessive moisture in subgrade could cause problems for equipment
- Give adjacent property owners adequate notice prior to beginning work (we required 72 hours).
# FDR Recommendations

<table>
<thead>
<tr>
<th>Location</th>
<th>Length</th>
<th>C&amp;G/ SP</th>
<th>Surface Course</th>
<th>Base Course</th>
<th>CBR</th>
<th>PCI</th>
<th>FDR Depth</th>
<th>New Surface</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dana Ln</td>
<td>2100</td>
<td>SP</td>
<td>1.5&quot; AC</td>
<td>5&quot; CABC</td>
<td>7</td>
<td>21</td>
<td>7&quot;</td>
<td>2&quot; S9.5B</td>
</tr>
<tr>
<td>Englewood Dr</td>
<td>380</td>
<td>C&amp;G</td>
<td>3.5&quot; AC</td>
<td>6.5&quot; CABC</td>
<td>4</td>
<td>65</td>
<td>9&quot;</td>
<td>2&quot; S9.5B</td>
</tr>
<tr>
<td>Nicodemus Mile Rd</td>
<td>3500</td>
<td>SP</td>
<td>2.5&quot; AC</td>
<td>7.25&quot; STBC</td>
<td>9</td>
<td>32</td>
<td>8&quot;</td>
<td>3&quot; S9.5B</td>
</tr>
<tr>
<td>Southern Blvvd</td>
<td>450</td>
<td>SP</td>
<td>2.5&quot; AC</td>
<td>8&quot; STBC</td>
<td>50</td>
<td>56</td>
<td>8&quot;</td>
<td>2&quot; S9.5A</td>
</tr>
<tr>
<td>Stokes St</td>
<td>400</td>
<td>C&amp;G</td>
<td>2.5&quot; AC</td>
<td>8&quot; CABC</td>
<td>10</td>
<td>60</td>
<td>12&quot;</td>
<td>2.25&quot; l19, 1.25&quot; S9.5B</td>
</tr>
<tr>
<td>Wellington Dr</td>
<td>2700</td>
<td>SP</td>
<td>3&quot; AC</td>
<td>6&quot; CABC</td>
<td>5</td>
<td>32</td>
<td>8&quot;</td>
<td>2&quot; S9.5A</td>
</tr>
<tr>
<td>Davis St</td>
<td>1040</td>
<td>C&amp;G</td>
<td>3.8&quot; AC</td>
<td>5&quot; STBC</td>
<td>12</td>
<td>55</td>
<td>8&quot;</td>
<td>1.5&quot; S9.5B</td>
</tr>
<tr>
<td>Grace St</td>
<td>1450</td>
<td>C&amp;G</td>
<td>3.25&quot; AC</td>
<td>5.5&quot; STBC</td>
<td>25</td>
<td>60</td>
<td>9&quot;</td>
<td>2&quot; S9.5B</td>
</tr>
<tr>
<td>Fenner Rd</td>
<td>2600</td>
<td>SP</td>
<td>3.5&quot; AC</td>
<td>8&quot; CABC</td>
<td>4</td>
<td>65</td>
<td>9&quot;</td>
<td>3&quot; S12.5B</td>
</tr>
</tbody>
</table>
Streets Deleted After Start of Project

- **Davis St, S. Grace St.**
  - Concern over damaging AC and lead joint pipe

- **Fenner Rd**
  - Sections of extremely thick asphalt and spot locations of very poor subgrade

- **Starling Way**
  - Spot locations of clay subgrade missed in core sampling and highly saturated subgrade and would not support milling machine
Streets Added After Start of Project

- Mansfield Dr, Augustus Dr, Southern Blvd
  - All streets were ditch sections with highly degraded pavement and soil type base course or a thin stone base.
  - Experience on previous sections had provided a high level of confidence in using FDR on these types of street sections
Problems Encountered

- Shallow Storm Drain
  - Blind junction and RCP less than 8" of cover discovered with the milling machine
- Crown section needs to be graded into the reclaimed base course before mixing in cement
  - Once cement has set up it can’t be re-graded. Problem was remedied after the first street
- Weak spots
  - Locations of weak subgrade or high moisture resulted in spot locations of weakness. Re-milling with additional depth and cement bridged these locations.
  - Proof-roll after 7 days and/or prior to resurfacing to identify weak spots in base and sub-base.
- Traffic Control
  - More intensive than patching, but not as problematic as reconstruction.
## Summary of FDR
### Completed/Proposed

<table>
<thead>
<tr>
<th>Resurfacing Contract</th>
<th>Centerline Miles</th>
<th>Area (yd^2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>FY 2009</td>
<td>3.4</td>
<td>49,720</td>
</tr>
<tr>
<td>FY 2011</td>
<td>3.91</td>
<td>60,255</td>
</tr>
<tr>
<td>FY 2013</td>
<td>1.65</td>
<td>26,183</td>
</tr>
<tr>
<td>FY 2015</td>
<td>3.79</td>
<td>54,560</td>
</tr>
<tr>
<td>FY 2019</td>
<td>1.95</td>
<td>28,820</td>
</tr>
<tr>
<td><strong>Total =</strong></td>
<td><strong>14.7</strong></td>
<td><strong>219,538</strong></td>
</tr>
</tbody>
</table>
FY 2013 FDR
FY 2015 FDR
Summary

- FDR has worked very well on ditch section streets.
- Curb and gutter sections tend to have utility conflicts and require removal of excess material to allow for matching to curb.
- Be aware of subgrade moisture and be prepared to encounter spot locations of weak subgrade. May need to increase mill depth and introduce additional cement.
- Streets reclaimed with FDR since FY09 have a much stronger pavement section than the original.
- Use of FDR versus reconstruction is less costly and resulted in a minimal impact on traffic compared to reconstruction. Work has been done with lane closures and streets remained open to local traffic. Reclamation typically took 3-4 days per section.
Summary …

- Quality Control
  - Adequate pulverization
  - Proper cement content
  - Proper moisture content
  - Adequate density
  - Adequate curing

- Secure the services of an experienced geotechnical firm to assist with pavement assessment and monitoring the FDR rehabilitation process.

- Expect and be prepared for changes.

- Communicate, communicate, communicate (up, down, and sideways).
Questions?

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