FDR Concepts: SCDOT Experience/History

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Figure 5. Typical pavement performance curve indicating the relative timing of various pavement treatments.
How do we best deal with distressed pavements that are sliding down the performance curve?

• Mill-and-fill with asphalt is effective if the pavement is structurally adequate for the future traffic but is suffering from “top down” distresses.

• Patching prior to overlay is effective if the patching is primarily to address initial construction variation or isolated weak areas.

• If the repair needs are widespread, FDR with Portland cement is the most cost-effective rehabilitation method.
Advantages of the FDR process with Portland Cement

• Use in-place materials
  – Saves money
  – Conserve virgin material
  – Saves energy by reducing mining and hauling

• Limits hauling of materials from site
  – Saves fuel and reduced traffic

• Maintains existing grade, restores the cross section, and easily adds additional width
  – Safety
Advantages of the FDR process with Portland Cement

• Reliably treats all types of pavement distress
  – Versatile and robust

• Reduce construction time
  – Safety
  – User cost
  – Energy wasted due to delay
Advantages of the FDR process with Portland Cement

• Engineering benefits
  – Relatively impervious to environmental distress.
  – Typically provides the most economical pavement structure when future performance is considered.
  – Can substantially increase the existing pavement strength.
  – Provides a uniform cross section when widening.
When is FDR most appropriate?

- Distress indicates the pavement distress is in the base or subgrade
- Full-depth patching is required on more than 15 to 20 percent of the total surface area
- Existing asphalt thickness is 9 inches or less.
- Pavement structure is inadequate for current or expected future traffic.
FDR Construction Process

Pulverize, Shape, Add Cement, Mix In Place, Compact, and Surface

Asphalt Surfacing
- Granular Base
- Subgrade

Pulverized Subgrade
- Pulverization to desired depth
- Removal of excess material (if necessary) and shaping

Stabilized Subgrade
- Addition of cement, mixing, reshaping, and compaction

New Surfacing
- Stabilized Subgrade
- Final surface application
Road Mix

- Pulverize
- Spread cement
- Add water as necessary for Optimum Moisture and Mix
- Grade and compact
- Cure
- Overlay
Inside a Reclaimer

- Deep recycled layer
- Injection of water and/or fluid stabilizing agents
- Operating direction
- Milling drum
- Distressed pavement
- Granular material
Pulverization

- Pulverize mat to appropriate gradation
- Usually, only one pass is required
- May wish to incorporate shoulder materials for widening.
Cement Spreading

Cement is spread on top of the pulverized material in a measured amount in either a dry or slurry form.
Blending of Materials and Moisture Addition

Cement is blended into pulverized, reclaimed material and, with the addition of water, is brought to optimum moisture
Reclamation Train
Compaction and Grading

Material is compacted to 96 to 98 percent minimum standard Proctor density and then graded to appropriate Plan lines, grades, and cross-sections.
Initial Compaction
Most Important Operation
Steel Wheel Final Compaction
Curing

Bituminous Compounds (cutbacks or emulsions)

Water (kept continuously moist)
South Carolina

- Fourth largest state-managed highway system in US, based on centerline mileage.
- Lowest disbursements per mile ($39k versus national average of $162k.)
- State Highway Fund is 90% dependent on motor fuel fees versus national average of 35%.
- Motor fuel fees have not been raised since 1987.
- Considering inflation, current user fee buying power is only 50% of 1987 level and 15% of 1950 level.
Primary System, Federal Aid Eligible

- 9472 centerline miles
- 23,869 lane-miles
- Comprised of US and SC Routes
- Includes routes on the National Highway System (NHS)
- 47% of all travel in SC occurs on the primary system

2014 Primary Pavement Conditions
- 54% Poor
- 20% Good
- 26% Fair

Source: State of SCDOT 2015 Data as of January 2014
Primary System, Federal Aid Eligible

Primaries:
9472 CL Miles
Carries 47% of VMT

10 Year Forecast:
Significantly Erode

% Good to Decline to ≈10%
Secondary System, Federal Aid Eligible

- 10,413 centerline miles
- 21,108 lane-miles
- Comprised of US and SC Routes
- Tends to be higher volume than non-FA eligible
- 17% of all travel in SC occurs on the FA eligible secondary system

Source: State of SCDOT 2016
Data as of 12/31/2014
Secondary System, Federal Aid Eligible

FA Eligible
Secondaries:
10,413 CL Miles
Carries 17% of VMT

Pavement Conditions: Federal Aid Eligible Portion

- 2008: 31% Good, 50% Fair, 19% Poor
- 2009: 37% Good, 44% Fair, 19% Poor
- 2010: 40% Good, 46% Fair, 14% Poor
- 2011: 41% Good, 43% Fair, 16% Poor
- 2012: 41% Good, 42% Fair, 17% Poor
- 2013: 43% Good, 37% Fair, 20% Poor
- 2014: 46% Good, 33% Fair, 21% Poor

10 Year Forecast:
Continue to Decline

% Good to Decline to ≈15%
Secondary System, Non-FA Eligible

- 20,821 centerline miles
- 41,758 lane-miles
- 30% are in urban areas, comprising over 12,000 individual segments
- 7% of all travel in SC occurs on the non-FA eligible secondary system

Source: State of SCDOT 2016
Data as of 12/31/14
What is the condition of the pavement?

Non-FA Eligible Secondaries: 20,821 CL Miles Carry 7% of VMT

Pavement Conditions: Non-Federal Aid Eligible Portion

- 2008: 33% Good, 53% Fair, 14% Poor
- 2009: 35% Good, 53% Fair, 12% Poor
- 2010: 44% Good, 42% Fair, 14% Poor
- 2011: 46% Good, 41% Fair, 13% Poor
- 2012: 45% Good, 42% Fair, 13% Poor
- 2013: 50% Good, 40% Fair, 10% Poor
- 2014: 54% Good, 34% Fair, 12% Poor

10 Year Forecast: ACT 98 will begin to slowly improve % Good to ≈20%

but % Poor will continue to outpace repairs
South Carolina

• Prior to 1995, rehabilitation was full-depth patch and overlay or chip seal.
• Asphalt was relatively inexpensive and the system was in reasonably good shape because we paved thin and often.
SC Route 41, Johnsonville, SC

• SC was the site of the world’s first scientifically controlled soil-cement in 1935.
• Jointly designed with PCA.
• Site is still carrying traffic today...
SC Route 41, Johnsonville, SC, 1935

Pulverizing Soil

Cutting in Cement

Mixing Water

Finishing
SC Route 41, Johnsonville, SC

1965

2014
SC Route 41, Johnsonville, SC
SC Route 97, SCDOT’s first FDR project
2015, Twenty years after FDR
SCDOT FDR Program

• SC-97 was considered a success, but no dedicated funding was available for further projects. District 4 continued to use maintenance funds to aggressively reclaim.

• Additional FDR projects outside of District 4 were done sporadically, but successfully, over next 5 to 7 years.
SCDOT FDR Program

- SCDOT had a number of poor-performing conventional rehabilitation projects in the mid-2000s.
- Materials office found that many roads with very high (some greater than 50%) full-depth patching were programmed for patching and overlay.
- Began recommending consideration of FDR for sections with patching in excess of 15%.
- Number of FDR projects began to increase around 2009.
Allison Creek Road, 2004
FDR performed in 2005-6
Allison Creek Road, 2006
Allison Creek Road. 2015
Old Pardue Road, 2004
FDR performed in 2005
Old Pardue Road, 2007
Old Pardue Road, 2015
Old Zion Road, 2007
Old Zion Road, 2015
SCDOT FDR Program

• FDR with Portland cement has become a primary tool for pavement rehabilitation in SC.
• SCDOT let 4,500,000 sy of FDR in 2014 throughout the entire state.
• SCDOT let 1,100,000 sy of FDR in February 2015 letting and 1,300,000 sy in November 2015. Estimate 2015 total at 8.7 million sy.
# SCDOT FDR Program

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<th>Year</th>
<th>Quantity (thousand of sy)</th>
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<tr>
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<tr>
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<td>2015</td>
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SCDOT FDR Program Prices 2009 to mid-2014

- Average cement cost = $112.19/ton
- Average FDR mixing price = $4.61/sy
- Average cement rate = 59 pounds/sy
- Net FDR cost = $7.91/sy
- Average price for full-depth patch = $45/sy
SC FDR Cost Savings

• Assume average reclaimed road would otherwise require 35% full-depth patching.
• 35% of 21,970,000 sy is 7,689,500 sy
• Patching cost would be $346 million.
• FDR cost was $174 million
• 2009 to 2015 Cost savings: $172 million
SC FDR Cost Savings

- Put another way, FDR has allowed SCDOT to do approximately an extra 3,088 lane-miles of rehabilitated pavement for free.
- FDR provides an inexpensive way to widening existing narrow lanes, which enhances safety.
Future

• SCDOT has established a quality improvement committee (QIC) for cement-treated bases, including FDR.

• SCDOT is looking at mechanistic approaches to cement treated base designs, including FDR.
Future

- SCDOT has over 275 million square yards of pavement in poor condition.
- At an annual rate of 5 million square yards, it would take approximately 55 years just to treat current backlog.
Future

• SCDOT OMR is looking at optimizing the cement rate and FDR mixing depth.
• Findings indicate that 10 inches of 300 psi CMRB will last longer than 8 inches of 600 psi CMRB in many applications.
• Lower strength and deeper mixing can cut cement rate by 40% and reduce cracking.
Questions?

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