Full Depth Reclamation with Cement

Stan Bland, P.E.
Southeast Cement Promotion Association
Pavement Applications Director, Carolinas/Virginia

Greensboro, NC
October 30, 2018
SC Route 41, Johnsonville, SC

- SC was the site of the world’s first scientifically controlled soil cement-treated base in 1935.
- Jointly designed with PCA.
- Site is still carrying traffic today...
ROAD SOIL STABILIZATION

STABILIZING SOILS WITH PORTLAND CEMENT, EXPERIMENTS BY SOUTH CAROLINA HIGHWAY DEPARTMENT

By W. H. MILLS, Jr.

Testing Engineer, South Carolina Highway Department

SYNOPSIS

Initial experiments with portland cement soil mixtures led in October, 1933, to the moulding of samples in the driveway of the laboratory to learn their resistance to weather and traffic. These samples, consisting of top soil and rich sand clay soil were used with varying amounts of cement. Their resistance to traffic was noticeably greater than that of the raw soil. The first field experiment, a 528-ft. section of road in good sand clay soil was constructed in December, 1933, the soil in place being pulverized, and cement applied to the surface at the rate of one bag per linear foot of 20-ft. roadway. Cement and soil were mixed dry, sprinkled, mixed wet, shaped and rolled. After being under traffic a year, the road was covered with a one-inch sheet asphalt wearing course. A few pot-holes developed prior to application of surfacing, but there was no indication of raveling or general break-down.

In the Summer of 1935 a test section known as the Johnsonville Experiment was undertaken with preliminary laboratory study of soil compaction and of
SC Route 41, Johnsonville, SC

• Construction was very, very, very, very slow...
  - 66 calendar days to treat 19,200 sy

• Today, similar quantity can be done in less than 2 days.

• Initially tried to shape the day after mixing.
  - Was too hard to blade out sheepsfoot dimples.
SC Route 41, Johnsonville, SC in 1935

Pulverizing Soil
SC Route 41, Johnsonville, SC

Applying Water
SC Route 41, Johnsonville, SC

Mixing Cement and Soil
Reclamation Train
SC Route 41, Johnsonville, SC
Quotes from paper...

• “The finishing operation consisted of blading the surface to the correct grade and cross-section with a hand-operated road machine. This operation determined the riding quality of the section and was done by very skillful operators...”

• “It was not possible with the equipment available to carry out the work so that a section could be finished during daylight, and grateful thanks must be paid to the operators of the finishing equipment for the smooth surfaces obtained.”

W.H. Mills
Testing Engineer,
SC Highway Department, 1937
The most important operation...still.
SC Route 41, Johnsonville, SC

Determining Moisture Content
SC Route 41, Johnsonville, SC

Testing Compaction
How much did it cost?

• Cement was $2.33/barrel ($10.96/ton)

• Labor rates were divided by skill
  - Skilled labor - $0.60/hr
  - Semi-skilled labor - $0.45/hr
  - “Common” labor - $0.30/hr

• Total cost:
  - Labor and equipment (gas, oil, and repairs only) - $0.168/sy
  - Cement - $0.216/sy
  - TOTAL - $0.384/sy
How much did it cost? (2017 dollars)

- Cement was $41.47/barrel ($195.08/ton)
- Labor rates were divided by skill
  - Skilled labor - $10.68/hr
  - Semi-skilled labor - $8.01/hr
  - “Common” labor - $5.34/hr
- Total cost:
  - Labor and equipment (gas, oil, and repairs only) - $2.99/sy
  - Cement - $3.84/sy
  - TOTAL - $6.83/sy
“No attempt will be made to draw definite, long range conclusions from this work at the present time. The action of weather and traffic will, in time, prove the merits of this method of stabilization. However, the present indication is that treatment of soils by the method described herein has appreciable merit and is possible and comparatively economical for many lightly travelled roads in South Carolina”

W.H. Mills
Testing Engineer,
SC Highway Department, 1937
SC Route 41, Johnsonville, SC

1965

Today...
SC Route 41, Johnsonville, SC
SC Route 41, Johnsonville, SC
SC Route 41, Johnsonville, SC
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.
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 Depth

• What depth is appropriate for FDR with Portland cement?
  - Cement stabilized bases are strong, but brittle
  - Will not perform if placed in a thin layer like flexible materials such as HMA
  - Recommendation:
    8 to 12 inches
Road Mix

- Pulverize
- Spread cement
- Add water as necessary for optimum moisture and mix
- Grade and compact
- Cure
- Overlay
Reclamation Train
The Blue Ridge Parkway
America’s Favorite Drive
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 97
SCDOT’s first FDR project
2018, Twenty-three years after FDR
2018, Twenty-three years after FDR
SC-97, York Co., Present Day
SC-97, York Co.,
Present Day
SC-97, York Co.,
Present Day
SC-97, York Co.,
Present Day
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, Current
Old Pardue Road, 2004
FDR performed in 2005
Old Pardue Road, 2007
Old Pardue Road, Current
Old Zion Road, 2004
FDR in 2005
Old Zion Road, 2007
Old Zion Road, Current
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 2017 throughout the entire state.
- SCDOT has done over 30 million sy of FDR since 2009.
SC FDR Cost Savings

• Assume average reclaimed road would otherwise require 35% full-depth patching.
• 35% of 30,007,000 sy is 10,502,000 sy
• Patching cost would be $473 million.
• FDR cost was $240 million
• 2009 to 2017 Cost savings: $233 million
Current FDR costs in SC

- For January-September 2018:
  - Full-Depth Patching - $48.70/sy
  - FDR Mixing - $5.72/sy
  - Portland Cement for FDR - $156/ton

- Assuming 60 pounds/sy of cement, break-even would be 21% patching.

- Suggest considering FDR when patching reaches 15%.
Raleigh Executive Airport
Raleigh Executive Airport
Raleigh Executive Airport
Raleigh Executive Airport
Elizabeth City Coast Guard Air Station/Regional Airport

Elizabeth City, NC
Virginia DOT FDR Program

I-81 In-Place Pavement Recycling Project


BRIAN K. DIEFENDERFER, Ph.D., P.E.
Senior Research Scientist
Virginia Center for Transportation Innovation and Research

ALEX K. APEAGYEI, Ph.D., P.E.
Research Fellow
Nottingham Transportation Engineering Centre
Figure 1. Completed Cross Section. AC = asphalt concrete; CIR = cold in-place recycling; CCPR = cold central-plant recycling; FDR = full-depth reclamation.
Implementing Research

• I-64 Lane Widening Project
  – Awarded 2016
  – 7.08 miles (~60 lane miles)

• Add travel lane and 12ft shoulder to the inside
  – CCPR base, asphalt surface layers

• Reconstruct existing lanes
  – Remove existing concrete
  – FDR foundation
  – CCPR base, asphalt surface layers
I-64, Alternative Sections

$71 / SY

2-in SM + 2-in IM
4-in BM
8-in Cement Treated Aggregate
Subgrade

$45 / SY

2-in IM + 2-in IM
6-in CCPR
12-in FDR
$6-$8/SY
Subgrade

Same structural value
36% lower cost
Potential Cost Savings

• Segment II
  – 7.08 miles x 3 lanes x 2 shoulders
  – 168,000 tons of CCPR
  – 345,000 SY of FDR
  – Cost savings using recycling > $10 million
    • as awarded

• Segment III?
  – 7.6 miles x 3 lanes x 2 shoulders
  – Cost savings could exceed $12-14 million
FDR with cement has many uses...

- National parks
- Airports
- Elementary schools to colleges
- Parking facilities
- Windmill and solar farms
- Interstate highways to subdivisions to rural secondary routes
- State DOTs to local governments to developers
- Inside buildings(!?)
Even inside buildings
Did it set up?
2019 FDR Symposium – Greensboro, NC

• April 24-25, 2019
• Koury Convention Center/Sheraton Greensboro
• Live demonstration in parking lot
• PDHs available
Thank you!

Stan Bland, PE
Pavement Applications Director – Carolinas/Virginia
s bland@secement.org
704-975-2951