Tomorrow's High Performance Concrete Pavements Today
Charlotte, North Carolina
February, 28, 2012
Full Depth Reclamation with Cement
A Tool That Should Be Available
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Full-Depth Reclamation with Cement
Introduction
Definition of Full-Depth Reclamation

- Method of flexible pavement reconstruction that utilizes the existing asphalt, base, and subgrade material to produce a new stabilized base course for a chip seal, asphalt, or concrete wearing surface.
Increased Rigidity Spreads Loads

Unstabilized Base

100 psi

15 psi

100 psi

4 psi

Full-Depth Reclamation
Reduced Moisture Susceptibility

High water table

Unstabilized Granular Base

Cement-Stabilized Base

Moisture infiltrates base:
- Through high water table
- Through capillary action
- Causes softening, lower strength, and reduced modulus

Cement stabilization:
- Reduces permeability
- Helps keep moisture out
- Maintains high level of strength and stiffness even when saturated
Rutting can occur in surface, base and subgrade of unstabilized bases due to repeated wheel loading.

Cement-stabilized bases resist consolidation and movement, thus virtually eliminating rutting in all layers but the asphalt surface.
When is FDR Appropriate

- The pavement cannot be rehabilitated with simple resurfacing.
- Distress indicates that the problem exists in the base or subgrade.
- Full depth patching is required of more than 15% to 20% of surface area.
- Pavement structure is inadequate for current or future traffic.
Types of Reclamation Methods

- Mechanical Stabilization
- Bituminous Stabilization
  - emulsified asphalt
  - expanded (foamed) asphalt
- Chemical Stabilization
  - portland cement
  - slag cement
  - fly ash
  - kiln dust
  - lime
  - other
Surfaced Roadways in the United States
(2,495,000 total centerline miles)

Flexible 82.2%
Composite 11.3%
Rigid 6.5%
Challenges Facing Our Roadways

- Continuing growth
- Rising expectations from users
- A heavily used, aging system
- Environmental compatibility
- Changes in the workforce
- Funding limitations

Combined with large increases in traffic volumes and/or allowable loads often leads to serious roadway base failures!
How do you know if you have a base problem and not just a surface deficiency?
Examples of Pavement Distress

- Alligator cracking
- Rutting
- Excessive patching
- Base failures
- Potholes
- Soil stains on surface
Advantages of the FDR Process

- Use of in-place materials
- Little or no material hauled off and dumped
- Maintains or improves existing grade
- Conserves virgin material
- Saves cost by using in-place “investment”
- Saves energy by reducing mining and hauls
- Very sustainable process
FDR Advantages

- The process allows for the widening of the existing road while creating a paved shoulder in one operation
- Creates a stronger shoulder and helps to eliminates possible cracking between the paved shoulder and the roadway
- Smaller scale construction operation
- Less equipment mobilization
FDR Advantages

- Ready for immediate local traffic use
- Higher load bearing strength
- Longer pavement Life
- Ability to treat all types of cracking and distress
- No worry about hit and miss full depth patches
- Makes use of our in place investment
- Significant savings
FDR Advantages

- Restores typical section
- Minimizes hauling
- Can be performed under a single lane closure
- Environmentally safe
- Reduces asphalt rates
- Improves the sub grades’ resistance to water penetration
- Fast operation
FDR Advantages

- We are recycling. 100% use of in place materials.

- This meets the GREEN Objective.
Benefits of FDR with Cement

- Increased rigidity spreads loads
- Eliminates rutting below surface
- Reduced moisture susceptibility
- Reduced fatigue cracking in asphalt surfacing
- Allows for thinner pavement section
## Rehabilitation Strategies

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Reclamation with Cement</th>
<th>Structural Overlay</th>
<th>Removal and Replacement</th>
</tr>
</thead>
<tbody>
<tr>
<td>New pavement structure</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Fast construction</td>
<td>✓</td>
<td>✓</td>
<td>X</td>
</tr>
<tr>
<td>Minimal traffic disruption</td>
<td>✓</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Minimal material in/out</td>
<td>✓</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Conserves resources</td>
<td>✓</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Maintains existing elevation</td>
<td>✓</td>
<td>X</td>
<td>✓</td>
</tr>
<tr>
<td>Low cost</td>
<td>✓</td>
<td>X</td>
<td>X</td>
</tr>
</tbody>
</table>
1 mile of 24-foot wide, 2-lane road, with a 6-inch base
Design
Pavement Thickness Design Procedures

- 1993 AASHTO Pavement Design Guide
  - Structural Numbers
  - Layer Coefficients
- New AASHTO Design Guide
  - Mechanistic-Empirical Design
  - Evaluates effects of pavement materials, traffic loading conditions, environmental factors, design features, and construction practices
When should we consider Reclamation

- When Full Depth Patching has reached 5% we need to take a serious look at FDR.

- At 12% TO 15% Full Depth Patching, we can perform FDR on the entire road for the same cost and eliminate the guess work of a patching hit and miss scenario.
So, when money is designated for contract work, how are the roads and the type of construction method decided???
Director of Maintenance furnishes Districts

A List of Qualifying Rds. (for each County)

- District selects roads
- Prioritized by formula
- Use OMR software for suggested methods
- Ride roads and finalize recommendations
- If in doubt contact OMR
- Prepare for contract letting
Resurfacing Contracts

- We want to select the best and most economical method to prepare the road for overlay.
- We need to avoid early and hard to explain premature failure.
- We are selecting the method that will best save future maintenance dollars. Low to minimal maintenance saves time and money.
- We refer to FDR as recycling rather than reconstruction.
FDR DESIGN

- Samples taken at different points along the roadway by contractor to get representative data.

- Certified lab mixes samples together to attain an average sample for testing. (by Contractor)

- Lab test results submitted to OMR for evaluation and recommendations.

  ** Design based on .26 Structural coefficient/inch, and we look for a 600 psi when it is practical.**
Laboratory Mix Design

- Obtain representative samples of roadway material
- Usually about 100 pounds of material is required
- Run sieve analysis (ASTM C136)
- Determine the max. dry density and opt. moisture content at various cement percentages (ASTM D558)
- Typical designs vary between 2 and 8 percent cement by weight of dry material
- Prepare samples
- Cure samples
Strength Determination

- Unconfined Compressive Strength Testing
  - ASTM D1633
  - Used by most governing agencies
  - Simple and quick procedure
  - 7-day strengths ranging from 300 to 400 psi are generally recommended
  - Proven strength (support) under extremely heavy traffic conditions
  - Proven performance (durability) in wet-dry and freeze-thaw environments
FDR Construction Process
Pulverize, Shape, Add Cement, Mix In Place, Compact, and Surface

<table>
<thead>
<tr>
<th>Bituminous Surfacing</th>
<th>Granular Base</th>
<th>Pulverized</th>
<th>Pulverized</th>
<th>Stabilized</th>
<th>Stabilized</th>
</tr>
</thead>
<tbody>
<tr>
<td>Subgrade</td>
<td>Subgrade</td>
<td>Subgrade</td>
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<td>Subgrade</td>
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</tr>
<tr>
<td>Existing road</td>
<td>Pulverization to desired depth</td>
<td>Removal of excess material (if necessary) and shaping</td>
<td>Addition of cement, mixing, reshaping, and compaction</td>
<td>Final surface application</td>
<td></td>
</tr>
</tbody>
</table>
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
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.
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.
Curing

Bituminous Compounds (cutbacks or emulsions)

Water (kept continuously moist)
Testing Requirements

Gradation/Uniformity

A common gradation requirement is for 100 percent to pass a 3-inch sieve, a minimum of 95 percent to pass a 2-inch sieve, and a minimum of 55 percent to pass a No. 4 sieve (ASTM C136).

Density

A common density requirement is to be between 96 and 98 percent of the established laboratory standard Proctor density (ASTM D558).

Moisture

A common moisture requirement is to be within 2 percent of the laboratory established optimum moisture content (ASTM D558).
Traffic and Surfacing

- Completed FDR base can be opened immediately to low-speed local traffic and to construction equipment.
- Subsequent pavement layers can be placed at any time.
Performance
Concluding Comments

- Use of in-place materials
- Very sustainable process
- Fast operation
- Constructed under traffic
- Structurally better than granular base
- Can apply local traffic almost immediately
- 30 to 60 percent less expensive than removal and replacement
Figure 5. Typical pavement performance curve indicating the relative timing of various pavement treatments.
Figure 2. Anticipated effect on pavement performance of multiple preventive maintenance treatments.
In South Carolina The Situation Is Simple

- SC has the Fourth Largest Highway System
- SC is near the bottom in funding
- 16 cents gas tax (No increase since 1987)
- The under designed system is failing rapidly
- Can’t afford failure and must spend money wisely. Every dollar has to be maximized
- FDP / Overlay and FDR / Overlay can be in the same contract. FDR and FDP (both prepare base for Resurfacing)
Full Depth Reclamation is a process whose time has come..........its environmentally sound, gives enhanced performance, and it saves dollars.
Life Cycle Tools for Full-Depth Reclamation

- **Life Cycle Cost Analysis (LCCA)** is an economic procedure used to compare competing design alternatives, over the lives of each alternate, considering all significant costs and benefits, expressed in equivalent dollars.

- **Life Cycle Assessment (LCA)** is the examination of a product's environmental aspects and potential impacts throughout its lifetime, including raw material extraction, transportation, manufacturing, use, and disposal.
FDR in South Carolina

How Does SC Measure Progress/SUCCESS

- SC has had FDR Contracts performed in 37 of its 46 counties.
- All of the seven districts of SC has active FDR contracts today.
- In the last three years, SC has contracted over 250 center line miles of FDR work.
- District 4 FDR Specialty Crew accomplished nearly 35 cl miles of work in its first year.
Using this environmentally friendly and cost effective process, SC is utilizing its in place investment to restore the typical section and creating a strong base that the road never had.

“FDR reduces future maintenance costs !!”
Why put a band aid on the problem...Fix it and take credit for a more permanent solution.
There are many parts to the puzzle when it comes to repairing failing roads
Allison Creek Road
Old Pardue Road
North Carolina Perspective

- Meetings in 10 of the 14 Divisions
- Very good discussions and learning process
- Most have a successful FDR story
- Interest expressed in RCC and in Expanding FDR Use
- Attended And Presented at Rigid Pavement Committee
- FDR is not considered for base preparation in resurfacing contracts (FDP is OK)
North Carolina Full-Depth Reclamation Using Cement Since 2003

DOT - County Road Project
City Project
Airport Project
South Carolina / North Carolina

- 14 years ago SC map would have been blank
- As SC became more comfortable with the process FDR grew rapidly.
- The interest in North Carolina is there
- The problems in North Carolina are similar if not identical to those in South Carolina
- FDR is a tool that we all need as we seek to best spend our limited funds and save maintenance dollars..
In SC, limited funds have to be spent on real solutions that spend the dollar wisely (SC tax still at 1987 level).

In SC, Maintenance gets the left over money / They depend on successful resurfacing projects (maintenance free years).

FDR is recycling and the public likes this Green Objective.
Full Depth Reclamation with Cement

Developing and expanding the use of this process as we create a comfort level / trust..

Questions ??

Stan Bland
PCA-SE