GEOTECHNICAL UNIT –
Geopavement Section

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Technicians: Norwood Boyette, John Matula

Supervisor: Kevin Sebold
Presentation Overview

- NCDOT FDR Investigation History
- Site Selection Troubleshooting
- FDR Mix Design – Performed by GEU
- NCDOT FDR Specifications, QA/QC
- Falling Weight Deflectometer Case Studies
NCDOT FDR History

- Started in July 2003
- Performed FDR investigations in 12 of 14 N.C. Divisions
- Investigated nearly 800 miles
- Completed FDR on over 400 miles
- Project sizes range from $\frac{1}{2}$ mile to 9 miles in length
84,785 Miles of State Maintained Roads

2017 North Carolina Roadway Miles

- Paved Primary: 15,063 Miles (76%)
- Paved Secondary: 64,522 Miles (18%)
- Unpaved: 5,200 Miles (6%)
FDR Lane Miles from the Beginning

Investigated vs. Completed

Year of FDR

Lane Miles

Investigated Lane Miles

Completed Lane Miles
785 Total Lane Miles 2003-2018

785 Investigated Lane Miles

- Completed Lane Miles: 423 (54%)
- Other Rehab Strategy or Awaits Funding Lane Miles: 362 (46%)
FDR Mix Design Process
(Takes 4 to 6 weeks)

Mix Design by NCDOT’s Geotechnical Unit

1. GEU Preliminary Investigation
2. GEU Roadway/Field Investigation
3. Laboratory Testing of Samples
4. Evaluate Data from Lab and Field Investigation
5. GEU Provides Design
GEU Preliminary Investigation - Photographs

1. Photograph intersections for street names
2. Focus on moderate to high severity distresses
3. Photograph bulk sample locations
FDR Preliminary Investigation – Concerns

Reasons for Potential FDR Rejection (rare)

- Unresolved Drainage Issues (Left)
- Very High ADT (Bottom Left)
- Road in Good Condition (below)
- Thick asphalt
FDR Preliminary Investigation – Avoiding Potential Rejection

• Resolve drainage issues: clear ditches, drains, pipes
• Very high ADT requires special traffic control or detour
• If road is in good condition:
  – Wait till road is no longer in good condition
  – If recent overlay, after a couple years, cracks and distressed areas reflect through new pavement
• Milling is required if asphalt thickness exceeds 5 inches, millings can be re-used
• If asphalt thickness is greater than 8 inches, may need to skip reclamation on those areas
Traffic Control is Absolutely Necessary

Pilot car or flaggers
GEU Roadway Investigation

Sampling Equipment
GEU Roadway Investigation – Sampling Procedures

- Pavement Layer Thickness: 4” Core
- Subgrade Strength: DCP
- Subgrade Investigation
- Dead Stem Auger to 5’
- Samples for Lab Testing:
  - Classification
  - Gradation
  - Unconfined Compressive Strength

Teeth are carbide-tipped buttons or blades.
Laboratory Testing of Samples

Bulk Samples Ready for Laboratory Submittal
Laboratory Testing of Samples – Results

Unconfined Compression Test Report (ASTM D2166)

<table>
<thead>
<tr>
<th>Proj. Sample No.</th>
<th>3X</th>
<th>4Q</th>
<th>5X</th>
<th>16Q</th>
<th>17X</th>
<th>18Q</th>
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</thead>
<tbody>
<tr>
<td>Lab. Sample No.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Retained #4 Sieve %</td>
<td>1</td>
<td>6</td>
<td>1</td>
<td>7</td>
<td>-</td>
<td>-</td>
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<tr>
<td>Passing #10 Sieve %</td>
<td>95</td>
<td>90</td>
<td>91</td>
<td>86</td>
<td>98</td>
<td>96</td>
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<tr>
<td>Passing #40 Sieve %</td>
<td>68</td>
<td>70</td>
<td>64</td>
<td>67</td>
<td>86</td>
<td>74</td>
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<tr>
<td>Passing #200 Sieve %</td>
<td>42</td>
<td>48</td>
<td>34</td>
<td>35</td>
<td>70</td>
<td>55</td>
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Unconfined Compression Stress Axial Strain Curve

MINUS NO. 10 FRACTION

<table>
<thead>
<tr>
<th>SOIL MORTAR - 100%</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
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</thead>
<tbody>
<tr>
<td>Coarse Sand Ret - #60 %</td>
<td>39.0</td>
<td>30.9</td>
<td>42.1</td>
<td>34.4</td>
<td>16.4</td>
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<tr>
<td>Fine Sand Ret - #270 %</td>
<td>21.2</td>
<td>20.2</td>
<td>25.3</td>
<td>31.5</td>
<td>18.6</td>
</tr>
<tr>
<td>Silt 0.05 - 0.005 mm %</td>
<td>9.4</td>
<td>16.5</td>
<td>12.4</td>
<td>15.9</td>
<td>16.5</td>
</tr>
<tr>
<td>Clay &lt; 0.005 mm %</td>
<td>30.3</td>
<td>32.4</td>
<td>20.2</td>
<td>18.2</td>
<td>48.5</td>
</tr>
<tr>
<td>Passing #40 Sieve %</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>HICAMS #</td>
<td>44</td>
<td>55</td>
<td>41</td>
<td>44</td>
<td>61</td>
</tr>
</tbody>
</table>

AASHTO Classification

<table>
<thead>
<tr>
<th>Station</th>
<th>Offset</th>
<th>Alignment</th>
<th>Location</th>
<th>Depth (Ft)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A-5(2)</td>
<td>RT</td>
<td>RT</td>
<td>160-00 180-00 200-00</td>
<td>to 200+00</td>
</tr>
<tr>
<td>A-7-5(7)</td>
<td>RT</td>
<td>RT</td>
<td>LT</td>
<td>180-00</td>
</tr>
<tr>
<td>A-2-5(0)</td>
<td>LT</td>
<td>LT</td>
<td>LT</td>
<td>200-00</td>
</tr>
<tr>
<td>A-7-5(17)</td>
<td>LT</td>
<td>LT</td>
<td>LT</td>
<td>160-00</td>
</tr>
<tr>
<td>A-7-5(12)</td>
<td>LT</td>
<td>LT</td>
<td>LT</td>
<td>180-00</td>
</tr>
</tbody>
</table>

(Above) Soil Gradation Classification

(Left) Unconfined Compression Results with 8% Cement
FDR Mix Design Process (Takes 4 to 6 weeks)

Evaluate Data from Lab and Field Investigation

- Combined lab results
  - Unconfined compressive strength
  - Subgrade classification results
- Roadway Investigation results
  - ADT
  - Subgrade
  - Existing Pavement Thickness
  - Classification of soils
  - DCP (subgrade strength) results
FDR Mix Design Process (Takes 4 to 6 weeks)

**GEU Provides Design**

- **FDR recommended depth**
  - Typically 12"
  - A few older FDR projects ranged from 8”-12”
- **Cement application rate**
  - For example: 40 lbs/sq yd
  - Target is 300 PSI (Range 200 – 400)
- **Final Asphalt thickness**
  - At least 2 inches of asphalt
  - Minimum 2 lifts
- **MUST have fresh tack coat between FDR and asphalt**
GEU Provides Design – Notables

- Final minimum asphalt thickness of 2 inches
- It is highly recommended to place asphalt in 2 lifts
- Asphalt must be bonded to FDR with prime coat or heavy tack coat, FRESH tack coat is key
- Design should be based on anticipated 20-year traffic load

  ❖ Some divisions will triple seal for short-term use, then lay asphalt pavement the next year with their new budget.
GEU Provides Design – In Summary

<table>
<thead>
<tr>
<th>What Geotechnical Unit does for you:</th>
<th>What we need from you:</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Investigates roadway(s)</td>
<td>1. Traffic control (flaggers)</td>
</tr>
<tr>
<td>2. Submit samples</td>
<td>2. Advance Warning Signs</td>
</tr>
<tr>
<td>3. Sample analysis</td>
<td>3. Cold patch or other approved patching materials</td>
</tr>
<tr>
<td>4. Design cement rate</td>
<td>4. Patch hole</td>
</tr>
<tr>
<td>5. Design FDR depth</td>
<td></td>
</tr>
<tr>
<td>6. Provides Asphalt Overlay Design</td>
<td></td>
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</tbody>
</table>
Specifications and QA/QC

Nuclear Gauge

“Ring” Test

Compressive Strength Pills

State Inspectors

M & T

GEU

Specifications (Section 541)
Steps in FDR

1. Premix/Pulverize
2. Spread Cement
3. Mix: Dry and H₂O
4. Compact
5. Grade
6. Pave
Reclaimer Requirements: Self-propelled Mixer, with at least 400 HP and spray bar in mixing drum
Spec’s on Spreading Cement

- Spread cement with variable rate spreader calibrated to prescribed rate.
- The Portland cement must be Type I, II, or 1S. (Division 10, Article 1024-1)
Spec’s on material - Dry Mixing

- At or Below Optimum Moisture Content
- 100% Passes 2-Inch Sieve
- 50% Minimum Passes #4 Sieve
- Do not pulverize more than can be finished in the same day
Spec’s on Wet Mixing

- Direct hookup with water to reclaimer helps prevent water runoff and inconsistent moisture range.
Spec’s on Wet Mixing

• Water from “local” source must have pH from 4.5 to 8.5
• Watch Moisture:
  – Optimum to 1.5% above optimum
Spec’s on Compaction

• Optimum to 1.5% above optimum moisture
• Minimum 97% density by AASHTO T-99:
  – Materials and Test Unit (M&T)
  – Inspectors
• Nuclear Gauge option:
  – Materials and Test Unit (M&T)
  – Inspectors
• 3 hours to finish after water is added
• 30 minute undisturbed time limit
Spec’s on Grading, Curing, and Traffic

• Grade to + or – ½ inch
• Curing: 7 days (can vary depending on circumstances).
• Finished FDR must be protected from freezing temperatures.
• FDR can be opened to local lightweight traffic at end of each day’s construction.
• Finished FDR must be kept moist until it is seal coated, another surface treatment or the next pavement course is applied.
Ring Test
Determining Unit Weight of FDR Material
Nuclear Test Strip
Compaction

- M & T
- State Inspectors
- Density Testing:
  - Ring Tests
  - Nuclear Gauge
  - Test Strip
  - Proof rolling
  - Testing of each FDR “pull” length
QA/QC: Quality Assurance

Unconfined Compression Samples

Clegg
QA/QC: Quality Assurance

CORES

DCP
Additional Non-Destructive Methods

Falling Weight Deflectometer (FWD)

Pavement Design and Collection Section
FDR Construction and QA/QC – Summary

- Calculate pull area
- Calibrate cement spread
- No rocks greater than 2 inches
- 50% or above passing #4 sieve
- Proper equipment
- Well mixed
- Optimum moisture to 1.5% above optimum
- 3 hour time limit
- Grade within ± ½”
- Minimum 97% density AASHTO T-99
- Cure for 7 days (variable)
Falling Weight Deflectometer Case Studies

Moss Hayes Road

Lebanon Church Road

Shearon Harris Road

V.O.A. Site B Road
What is the Falling Weight Deflectometer (FWD)?

- Simulates a truck load on the road surface
- Measures the deflection
- FWD Data used to determine
  - Strength of the road (PSI, CBR)
  - Individual layer stiffness
Falling Weight Deflectometer Case Studies

- Goal: The Geotechnical Engineering Unit will observe the competency of FDR roads over time.
- Falling Weight Deflectometer (FWD) Data:
  - Strength of the road (PSI, CBR)
  - Individual layer stiffness
- Deflection of 3 mils (0.003”) is often seen in concrete roadways
- Pavement Design and Collection defines deflection limits for each roadway
Lebanon Church Road, Northampton County

- Division 4, Coastal Plain Region
- Length = 3.44 lane miles
- Pavement before FDR = 4” to 8” of varying pavement types, including sand asphalt and BST
- 20’ average width
- Traffic = 920 ADT with 15% TTST
- Agricultural machinery and equipment, logging trucks, and passenger car traffic
Lebanon Church Road, Northampton County Division 1

- FDR Construction 2013
- Wood Pallet processing facility, asphalt plant, and a storage area for sand and gravel
- Deflection Limit is 6 times the highest deflection
- Asphalt over 12” of FDR:
  - 2.0” S9.5C
  - 2.5” I19.0C
Before FDR – September, 2011
During FDR – September, 2013
After FDR – April, 2017
After FDR – April, 2017
Before: 2011

AFTER: 2017
VOA Site B Road, Pitt County

- Division 2, Coastal Plain Region
- Length = 3.9 miles
- Pavement before FDR = 0” to 5” of asphalt pavement, with large areas of 16” ABC only
- Rate = 60 lbs. cement/sq yd
- Special Case: ABC patched areas – from 80’ to 360’ long and 16” deep – Rate = 45 lbs/yd²
- 20’ average width
- Traffic = 375 ADT, 12% Duals, 16% TTST
V.O.A. Site B Road, Pitt County Division 2

- FDR construction in 2011 and 2012 (split into 2 sections)
- Deflection limit is more than twice the highest deflection
- Asphalt over 12" of FDR:
  - 3.0" S9.5B
  - Placed in 2 lifts
Shearon Harris Road, Wake County Division 5

- FDR Construction 2011
- This road is well traveled by trucks, nuclear plant
- Average Deflection is between 3 and 4 mils
- Deflection Limit is 4 times higher than highest deflection
- Asphalt over 12” of FDR:
  - 1.5" S9.5B
  - 2.5" I19.0B
Shearon Harris Road, Wake County

Before
November, 2011

After
February, 2017
Shearon Harris Road, Wake County

Before: November, 2011

After: February, 2017
Moss Hayes Road, Granville County Division 5

- FDR Construction September 2011
- Average deflection about 7mils
- Deflection Limit is nearly 5 times higher than highest deflection
- 12” of FDR Base
- Overlay with triple seal
Questions