



Case Study of FDR on MD 980-B



Robert Hackman, P.E.

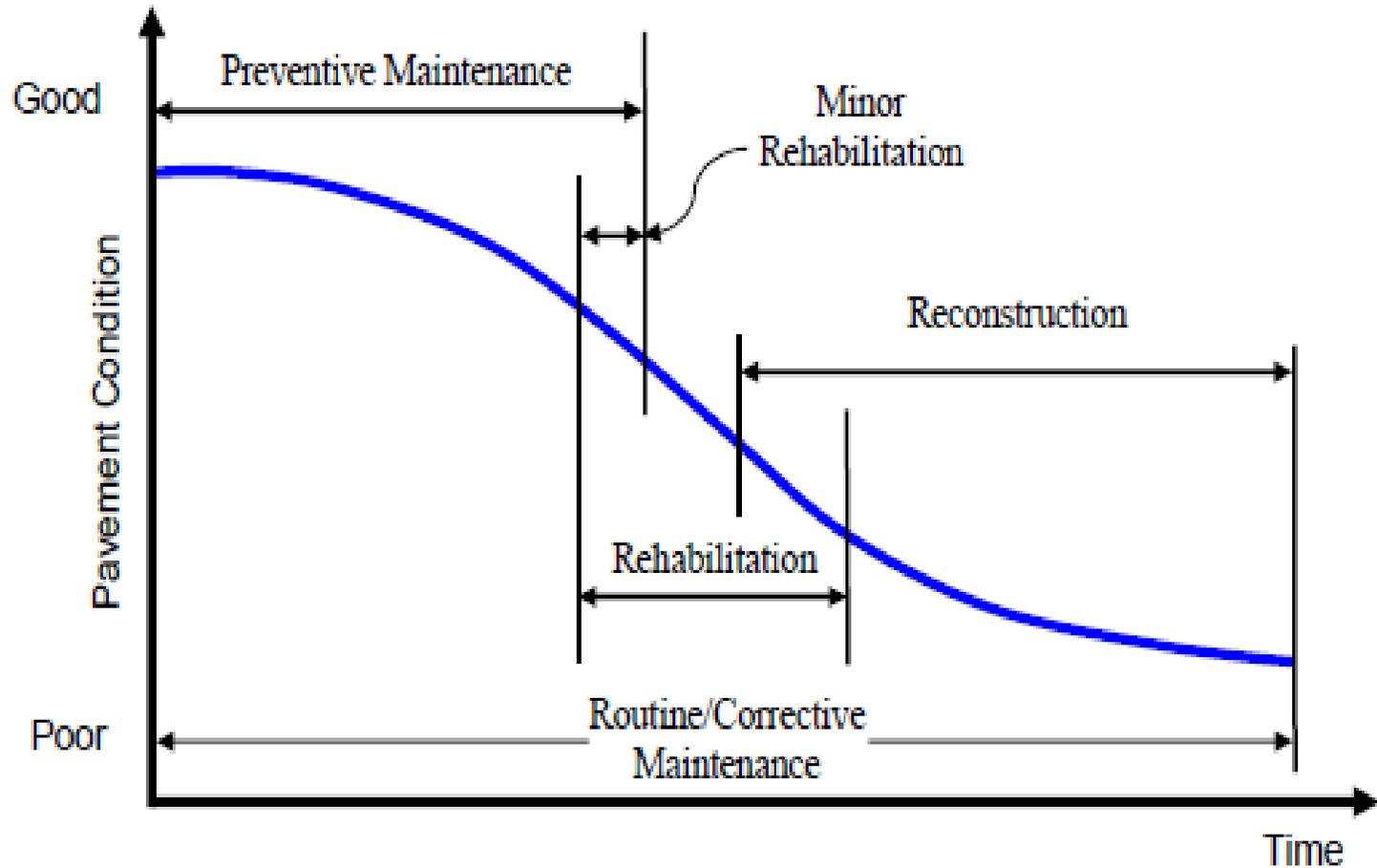


Evan Howard, OMT

What is FDR?

- ❖ **Full Depth Reclamation with Portland Cement**
 - Rehabilitation method utilizing existing pavement materials mixed with cement for a stabilized base course topped with new wearing surface.
 - The stronger cemented base is more consistent, and more moisture resistant, resulting long life, low maintenance, and increased vehicle capacity.
 - Applicable to Streets, Roads, Shoulders, Parking Lots

Pavement Performance Curve



Fast, Economical, and Sustainable rehabilitation

- Removal & replacement
- Thick structural overlays
- **Full depth reclamation**

Local roads are typically low-volume flexible pavements

When is the FDR Process Appropriate?

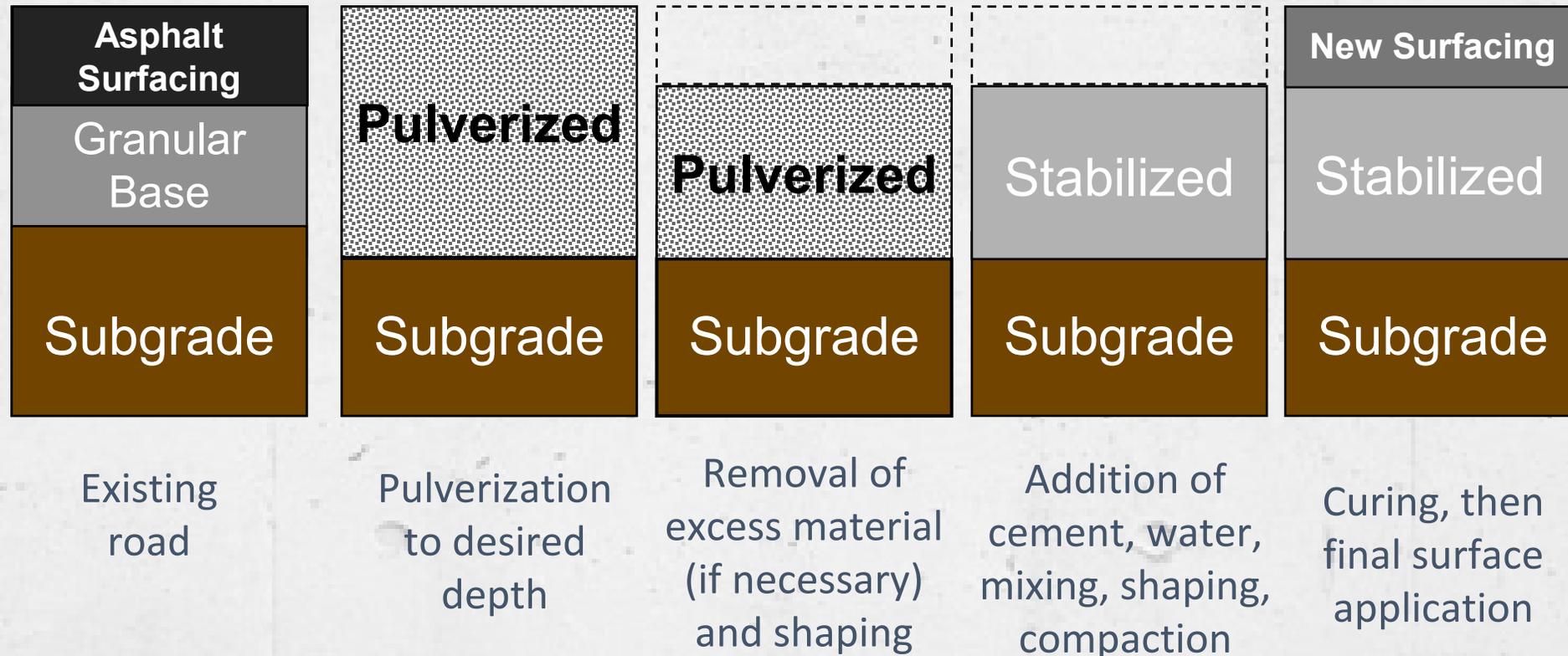
- Spending increasing amounts of money for maintenance
 - Pavement distress is due to base or subgrade failures
 - Full-depth patching is required on more than 15 to 20 percent of the total paved surface area
 - Pavement structure is inadequate for current or expected future traffic.
- ❖ **Resource**: “**Guide to Full-Depth Reclamation (FDR) with Cement**” CP Tech Center, March 2017
(available at www.cptechcenter.org)

Is Your Pavement A Candidate For FDR?

1. Perform pavement condition survey
 - a. Identify type of distress, severity, and quantity of impacted road
2. Determine existing pavement materials, subgrade, layer thicknesses
 - a. Cores/probes, test pits, sampling, laboratory tests
 - b. Mix design: % cement, moisture, density, target strength
3. Consider drainage conditions, grade and elevation restrictions
4. Estimate expected future traffic and/or use (Service Life)
5. Evaluate preliminary design FDR pavement section
6. Compare FDR costs to conventional pavement rehab solutions

FDR Construction Process

Pulverize, Add Cement, Mix In Place, Shape, Compact, and Install Surface Wearing Course



Core Examples of Full Depth Reclaimed Pavement Materials



Advantages of the FDR Process

➤ **Money Saving Pavement Strategy**

- Uses existing in-place materials (assets already paid for in previous pavement construction)
- Eliminates or reduces need for costly virgin materials
- Saves energy by reducing mining and processing
- Reduces trucking costs by limiting haul-off and dumping from site
- Saves fuel and reduces truck traffic on adjacent pavements
- Relatively simple process with fast design, bid and construction
- Provides an economical, long-lasting pavement
- Allows for conversion of existing shoulders to traffic bearing lanes

Advantages of the FDR Process

➤ Engineering Benefits

- Reliably treats most types of pavement distress
- Versatile for many pavements materials including some soil
- Increased stiffness/rigidity spreads out tire loads
- Reduces moisture/frost susceptibility of below surface materials
- No movement of below surface materials
- Eliminates rutting in below surface materials
- Results in **increased structural capacity** with long life
- Maintains existing grade and allows restoration or improvement to cross section and drainage issues

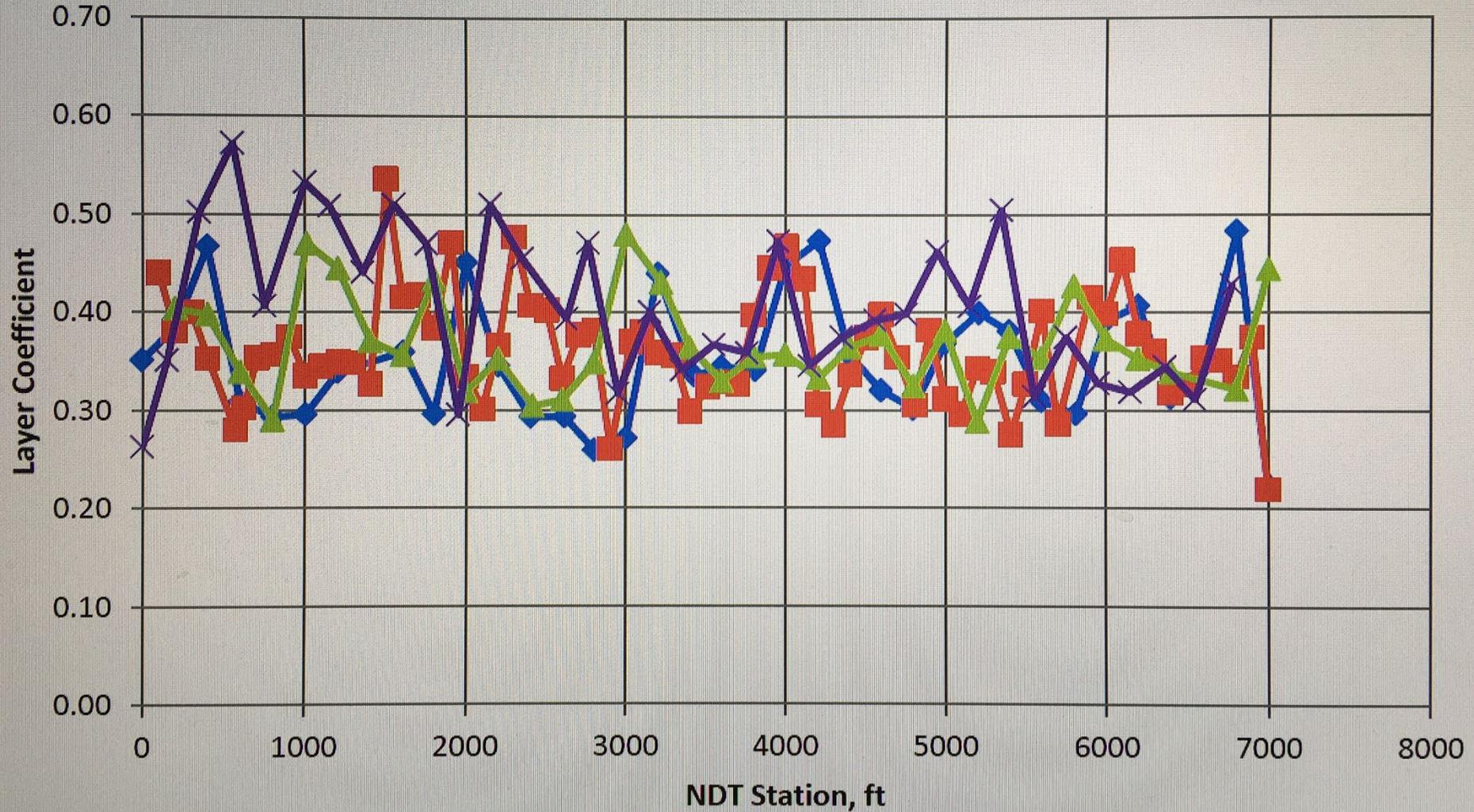
Thicker is Better? - Effect of Base Thickness

Base Thickness (inches)	Tensile Stress (psi)	Stress Ratio	Loads to failure (MEPDG)
3	181	1.3	1
6	100	0.71	1,200
8	71	0.51	389,000
9	61	0.44	2,900,000
10	53	0.38	14,460,000
12	40	0.29	196,700,000

- For concrete and cement-treated bases, the fatigue life is generally expressed as the ratio of horizontal stress to the modulus of rupture.
- It is often assumed that if the ratio is less than 0.45 to 0.40, the fatigue life is also “infinite”.
- Increased thickness also lowers the depth of freeze/thaw and moisture effects

Layer Coefficient of FDR

Route EB Left Lane Route EB Right Lane
Route WB Left Lane Route WB Right Lane



Construction Testing Requirements

Gradation



A common gradation requirement is 100% passing 3-inch sieve, >95% passing 2-inch sieve, and >55% passing No. 4 sieve (ASTM C136).

Density



A common density requirement is 96% to 98% of the established laboratory established standard Proctor density (ASTM D558).

Moisture



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

Construction Verifications

- Check Cement Spread Rate from Mix Design
 - Convert % cement to pounds/square yard
 - Weigh amount of cement from calibrated spreader
 - Check yield of total pounds of cement over treated area
- Check Depth of Treatment
 - Depth gage on mixing equipment
 - Test hole with indicator chemical (phenolphthalein)
 - Core section after strength gain
- Check Compressive Strength/Modulus
 - Make split-cylinder mold samples
 - Core section and test in compression
 - Perform Falling Weight Deflectometer (FWD)



















Full Depth Reclamation Summary

- FDR is a fast, economical and sustainable rehabilitation process
- County/municipality achieves a long-lasting, high quality pavement at less cost than typical reconstruction
- Provides increased rigidity and uniform support
- Reduces moisture susceptibility, rutting in below surface layers
- Increased base strength results in thinner surface layers
- Stabilized base materials result in little to no base maintenance
- Consider for widening applications
- Can be overlaid with Concrete, HMA, Chip Seal, or other surface
 - No aggregate base needed

FULL DEPTH RECLAMATION WITH CEMENT MD 980B from Wrighton Rd to Talbott Rd Contract # AA1595177

Project Information:

- First Full-Depth Reclamation project completed by Maryland State Highway Administration.
- M.T. Laney – FDR contractor
- Construction begun in October; completed November 2016.
- Length: 2 lanes @ 0.64 miles
- Project located in Bristol, MD – Southern Anne Arundel County
- Project Cost: **\$530,000**



PERFORM DESK REVIEW

- Construction history/repair history.
 - Rehab in 1998 with a 2" Overlay of 12.5mm, 70-22 Asphalt Mix
- As-built plans of previous projects.
- Video log viewer of previous years.
- Traffic Condition
 - Low ADT; however, 20 % Truck Traffic
- PM Base data and performance condition of the roadway for (IRI, Cracking, Rutting and Friction).
 - IRI – (Poor Condition)
 - Rutting – Mediocre
 - Cracking - Poor
 - Friction – Very Good

PERFORM SITE ASSESSMENT

- Assess the distress types and severity of the pavement.
Perform Patching Survey.
- Is the pavement an open or closed section?
- Is there curb and gutter in the area?
- Are there Grade and Elevation Restrictions?
- Assess the existing drainage conditions.
- Check existing underground utilities.

VISUAL SITE ASSESSMENT OF MD 980B



Preliminary Cost Analysis

- Alternative 1: Full-Depth Patching & 4" HMA Overlay

Life Extension (Chosen)	15
Lane-Miles	1.28
LMY Benefit	19
Project Cost	\$ 830,000
\$/LMY	\$ 43,200

- Alternative 2: Full-Depth Reconstruction

Life Extension (Chosen)	25
Lane-Miles	1.28
LMY Benefit	32
Project Cost	\$ 750,000
\$/LMY	\$ 23,400

- Alternative 3: Full-Depth Reclamation(FDR) w/ Cement and 4" Overlay

Life Extension (Chosen)	25
Lane-Miles	1.28
LMY Benefit	32
Project Cost	\$ 530,000
\$/LMY	\$ 16,600

ALTERNATIVE SELECTED

Full-Depth Reclamation and 4" Overlay

Advantages of FDR

- Conservation energy and materials. of non-renewable resources.
- Elimination of all distresses.
- Improve Subgrade Deficiencies.
- Significant structural improvement achieved.
- Reduces future maintenance cost.
- Cost savings compared to other rehabilitation methods.
- Longer Design Life.

Disadvantages Other Alternatives

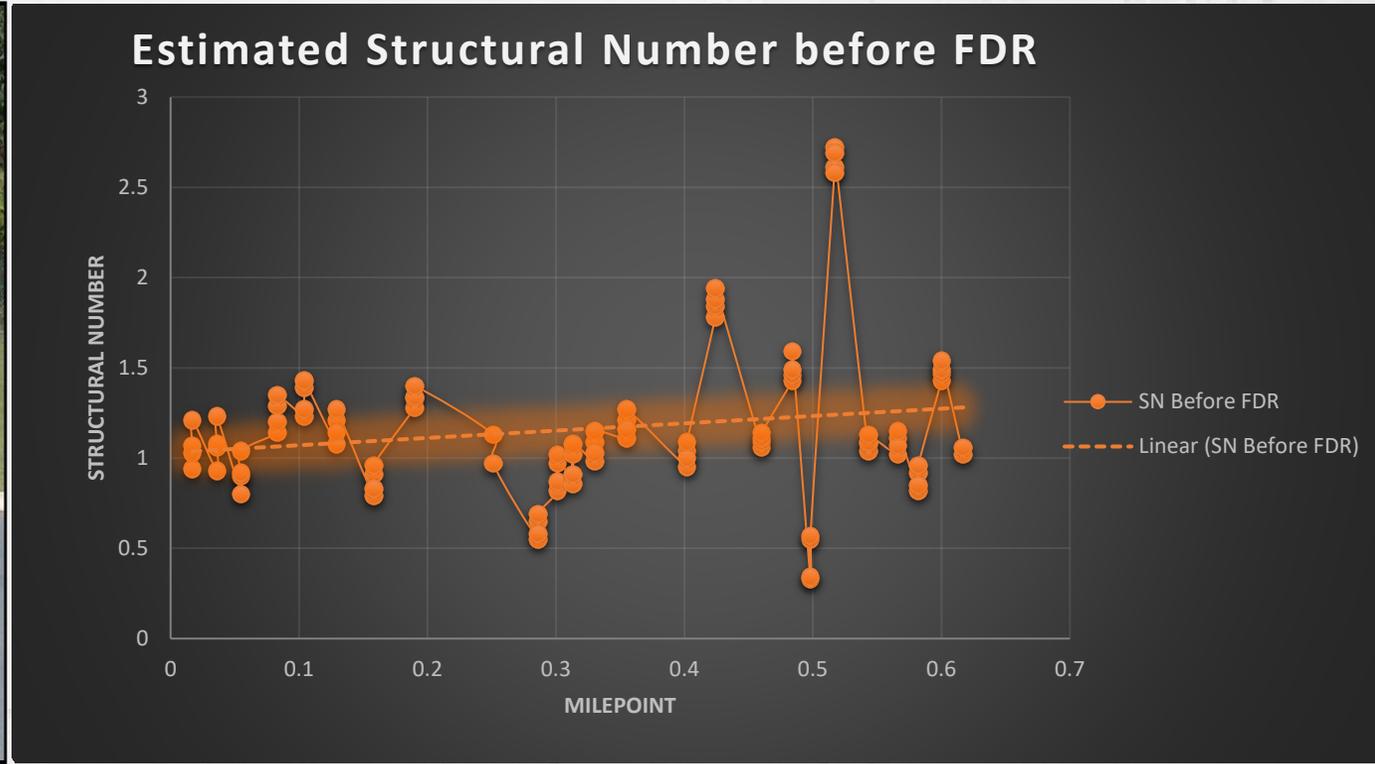
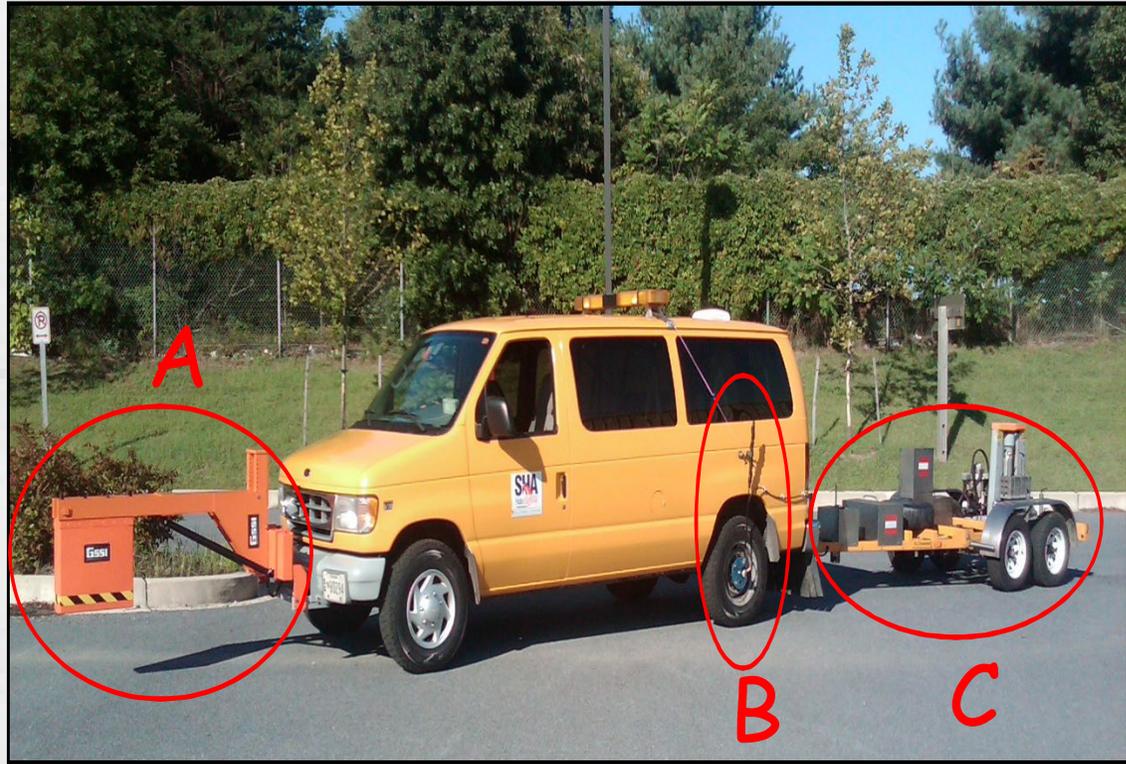
- Expensive Rehab cost.
- Stormwater Management Required.
- May require raising of the profile/grade.
- Potential for de-bonding / separation with the existing surface.



Perform Field Exploration and Sampling

- Performed FWD Testing which was used to determine some material properties.
- Performed Test Pits (1' x 1').
- Conducted laboratory mix design in accordance with MDOT SHA procedures.

Field Exploration: Falling Weight Deflectometer(FWD)



- A. 2.0 GHz horn antenna**
- B. Wheel-mounted Distance Measuring Instrument (2 Readings Taken every foot)**
- C. Existing FWD equipment**

Field Exploration – Test Pits



Laboratory Mix Design



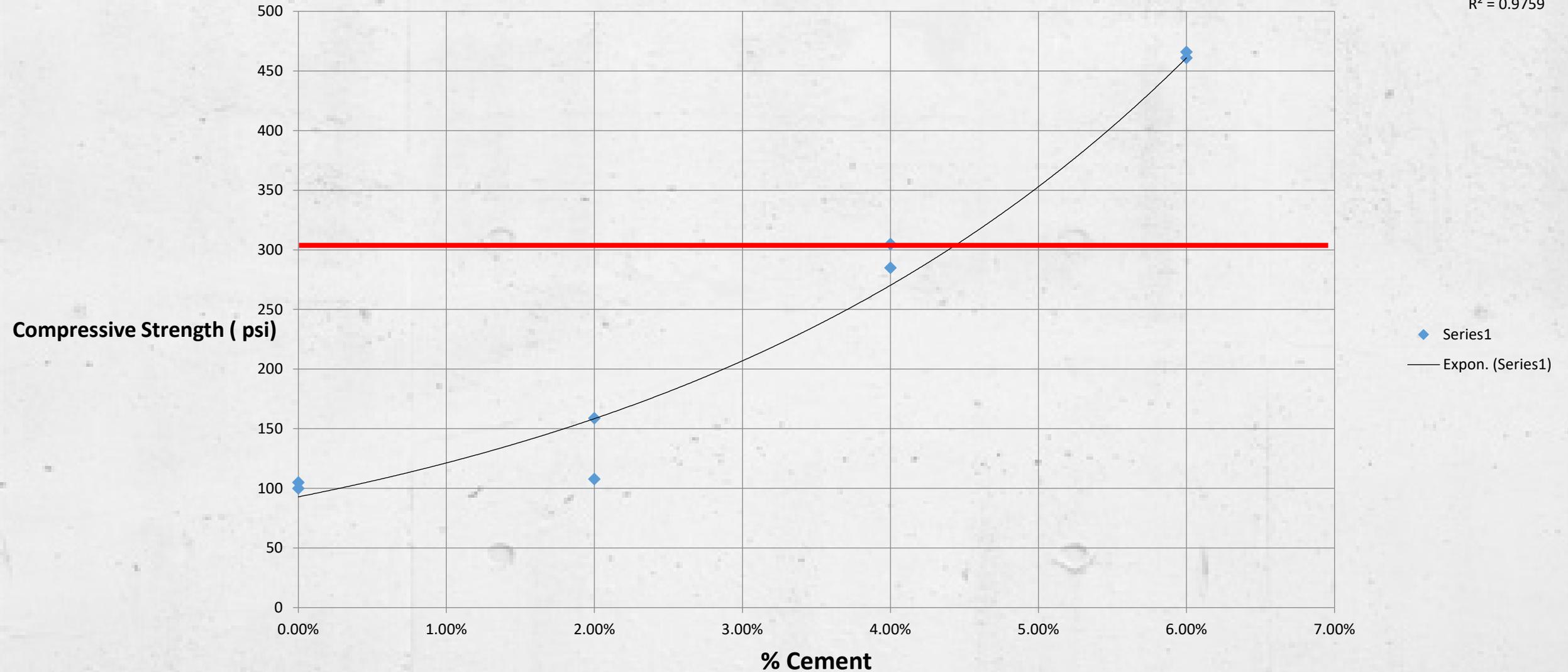
2013 01 12

2013 01 12

Mix Design

Compressive Strength vs. % Cement

$$y = 92.924e^{26.693x}$$
$$R^2 = 0.9759$$



Pavement Recommendations

- Pulverize existing roadway and subgrade to depth of 10 inches.
- Mix and stabilize the existing roadway and subgrade with 5 % Cement at a application rate of 59 lbs/sy.
- Compact the FDR Base to the following Target Density:
 - Maximum Dry Density – 133 pcf
 - Optimum Moisture – 7 %
- Allow the FDR mix to cure for 7 days to achieve a compressive strength of 300 psi.
- Place a 4-inch Asphalt Pavement (SuperPave Asphalt Mix 12.5 mm for Surface, PG 64-22, Level 2).

Maintenance of Traffic on MD 980B



Maintenance of Traffic on MD 980B

- MD 980 B is used as MTA Bus Route to connect Bristol Park and Ride to Lower Pindell Park and Ride.
- MD 980 B roadway closed for 1 month to allow for construction.
- Users of Lower Pindell Park and Ride will be sent to Waysons Corner Park and Ride.
- MTA will still service the Bristol Park and Ride during the closure period.

FDR Construction Process – Before Any Work



FDR Construction Process – Pulverizing Road



FDR Construction Process – Addition of Cement



FDR Construction Process – Addition of Water



FDR Construction Process – Compaction & Curing



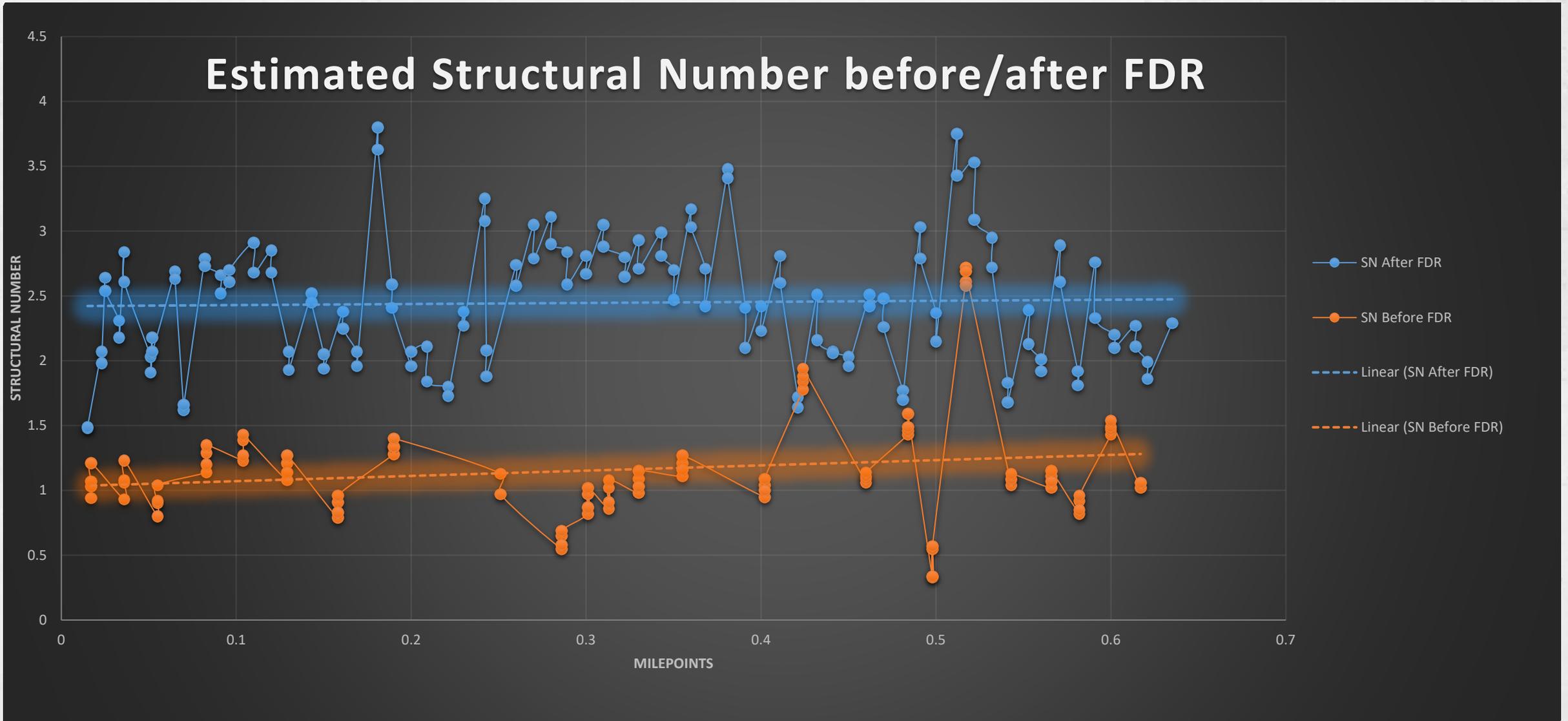
FDR Construction Process - Overlay



Quality Assurance – Acceptance Requirement

- The Contractor to submit a Mix Design for review and approval by SHA Office of Materials Technology.
- The Contractor to perform 500 ft Control Strip to verify that the construction equipment can meet the specification requirements.
- Make cylinder samples to determine if the FDR base meets the required compressive Strength of 300 psi.
- Use Nuclear Gauge to perform density checks to ensure that the FDR base is compacted to the required Maximum Dry Density and Optimum Moisture.

Comparison of FWD Results before/after FDR



Lessons Learned

- Cost effective rehabilitation method
- Include a Pre-Meeting with SHA inspector prior to start of project to discuss specification requirement of FDR.
- Include QA process to include calibration of cement spreader.
- Revise QA process to shorten frequency for compaction testing.
- Include QA process to check gradation of FDR.
- Include QA process to check cement rate of FDR.
- Extracting cores samples from the FDR base may be difficult.
- FWD testing can be used as a acceptable QA measure.

QUESTIONS



Robert Hackman, P.E.
ACPA
410-960-4822
acpapave@gmail.com

Evan Howard
MDOT SHA
443-572-5020
ehoward@mdot.maryland.gov