FDR Project Selection and Upfront Testing

Tom Scullion TTI

FULL DEPTH RECLAMATION WITH ASPHALT BINDERS
STATE OF THE ART
Spring 2020
Overview of Presentation

1. Challenges/Opportunities for FDR in Texas
   - TxDOT and Counties
2. Critical steps in FDR candidate evaluation and design process
3. Use of NDT in upfront testing
4. Case studies
Texas A&M Transportation Institute

TxDOT Challenges and Opportunities for FDR

- **Opportunities** No shortage of candidates
  - Roads with base problems
  - Energy Sector roadways
  - Inadequate width - make foundation layer

**Challenges**
- Variable pavement structure
- Construction on top of expansive clays
- Often poor existing base materials
- Early opening requirements in Energy Sector
Challenges for Counties

Sometimes High Growth
Heavy seasonal loads
Often very poor materials
Very thin layers
Working with Williamson County
Jeff Ivey Point of Contact

2 locations samples 8 inches deep

Dried, Sieve Analysis, PI - determines Job Mix options
Recommended Steps for Districts new to the FDR Design Process with Asphalt Binders

1. **Assemble Background information**
   - Coring logs
   - Maintenance
   - Typical section

2. **Non-destructive testing**
   - Ground Penetrating Radar (GPR)
   - Falling Weight Deflectometer (FWD)
   - Determine thickness & strength variability
   - Determine sampling locations

3. **Verify Pavement Structure & Sampling**
   - Auger or milling machine for sampling.
   - Drill logs for project
4. **Laboratory Mixture Design** *(Dale)*

- Plasticity Index
- Moisture-Density Curve
- Binder tests (foaming)
- Asphalt %, additive %, add rock % and foaming water %

5. **Pavement Thickness Design** *(Stephen)*

6. **Construction Quality Control** *(Richard)*

- Depth of pulverization
- Gradation
- Moisture content
- Emulsion content
- Foaming asphalt properties

7. **Construction Quality Assurance** *(Shane) – Density*

8. **Performance Evaluation** *(Tom) – FWD and Visual*
Step 1 Assemble Background Info

Typical section from candidate

1.5 inch Warrenite?
3.0 inch Bitulithic?
Step 2 Recommended NDT GPR
(use visual + GPR to select sampling locations)

- Integrated Video and FWD
- Data collected at highway speed (60 mph)
- Effective depth of penetration 20 ins
- TxDOT has 5 available units
- Measures layer thickness and locate subsurface defects and changes in base type
### Step 2 in the FDR Process

- Falling Weight Deflectometer (FWD)
- Subgrade Modulus determination

<table>
<thead>
<tr>
<th>Station</th>
<th>Load (lbs)</th>
<th>Measured Deflection (in)</th>
<th>Calculated Moduli (psi)</th>
<th>Absolute Deflection</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>R1</td>
<td>R2</td>
<td>R3</td>
<td>R4</td>
</tr>
<tr>
<td>0.000</td>
<td>9,266</td>
<td>1.99</td>
<td>8.16</td>
<td>0.49</td>
</tr>
<tr>
<td>0.104</td>
<td>9,201</td>
<td>6.73</td>
<td>2.98</td>
<td>1.88</td>
</tr>
<tr>
<td>0.201</td>
<td>9,321</td>
<td>26.21</td>
<td>15.94</td>
<td>7.49</td>
</tr>
<tr>
<td>0.301</td>
<td>9,510</td>
<td>12.98</td>
<td>8.20</td>
<td>3.50</td>
</tr>
<tr>
<td>0.400</td>
<td>5,623</td>
<td>5.91</td>
<td>2.03</td>
<td>1.65</td>
</tr>
<tr>
<td>0.500</td>
<td>7,277</td>
<td>7.91</td>
<td>3.96</td>
<td>2.30</td>
</tr>
</tbody>
</table>

**Note:** The table shows the modulus analysis system summary report with data for various stations and loads. The calculated moduli values are presented in psi, and the absolute deflection is measured in inches.
Step 3 Sampling

0.9 miles north

5 buckets of HMA
5 of base

4” HMA
6” FB
2” HMA

Use of GPR to select locations

Full Sample (mill)

Augur location Drill log + samples 2 ft into subgrade

DCP
Step 3 Sampling Equipment

Auger

Milling Attachment

Gradall
Basic Evaluation of project and materials
a) Thicknesses, b) Base Quality c) PI, d) Drill Logs
Critical Steps in the FDR Process

Coring Log
Why so much Upfront Testing?

TxDOT’s 1st foamed asphalt project (2000) < 1 year old

SEVERE RUTTING, ALLIGATOR & LONGITUDINAL CRACKING

CENTER/BETWEEN WHEELPATHS

OUTSIDE WHEELPATH

Recycled 10 inches deep - Problem: locally only 7 inches of pavement over black clay
TxDOT’s updated Stabilization Guidelines

Treatment Guidelines for Soils and Base in Pavement Structures

Geotechnical, Soils & Aggregates Branch
Materials & Pavements Section
Construction Division

August 2018
### Proposed Roadway Sampling Recommendations

#### Table 5. Sampling Roadway Materials.

<table>
<thead>
<tr>
<th>Step</th>
<th>Recommended Approach</th>
<th>Acceptable Approach</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Obtain historic plans. Conduct GPR survey.</td>
<td>Obtain plans and maintenance history.</td>
</tr>
<tr>
<td>2</td>
<td>Using plans and GPR survey, determine critical locations for sampling. Cover expected range of RAP and total pavement thickness.</td>
<td>Unless otherwise determined from plans and maintenance history, perform drill logs at 1 mi. spacing of the pavement structure including at least the top 10 in. of subgrade. For short projects (&lt; 1 mi.), sample and log a minimum of 3 locations.</td>
</tr>
<tr>
<td>3</td>
<td>Sample and log each location to include at least the top 10 in. of subgrade.</td>
<td>Review drill logs. Select locations representing significantly different materials for follow-up bulk sampling.</td>
</tr>
<tr>
<td>4</td>
<td>At each location of significantly different materials, use a small recycler or auger to obtain samples of materials expected in the road-mix. Typically, the top 8 to 10 in. of pavement contains these materials.</td>
<td>At each location of significantly different materials, use a small recycler or auger to obtain samples of materials expected in the road-mix. Typically, the top 8 to 10 in. of pavement contains these materials.</td>
</tr>
<tr>
<td>5</td>
<td>If RAP exceeds 2 in. in the existing pavement, maintain the RAP and salvage base separately.</td>
<td>If RAP exceeds 2 in. in the existing pavement, maintain the RAP and salvage base separately.</td>
</tr>
<tr>
<td>6</td>
<td>Collect approximately 400 lb. of sample for each set of different materials requiring a mixture design.</td>
<td>Collect approximately 400 lb. of sample for each set of different materials requiring a mixture design.</td>
</tr>
</tbody>
</table>
Case Studies

1. FM 3080 Tyler
2. SH 176 Odessa
3. SH 302 Odessa

- Is this an FDR Candidate
- Will one design work throughout
- Where to pull samples
- What recommendations for lab testing
FM 3080 Tyler District

Districts first Asphalt FDR project to be done with in house forces as a demo
Maximum FWD deflections
Very high throughout

Should be below this line
Sampling location 2 at TRM 630

Typical bad location 1” seals + 10 inch clay contaminated gravel base

Milling machine to pull samples
For lab FDR
Materials from Location 2
Poor gravel base and Clay subgrade

Clay Contaminated Gravel base  PI = 20  Field Moisture content around 10%
Lab results from FM 3080

FM 3080 Mixture Designs

Passing Designs

IDT Strength (psi)

Dry IDT

Wet IDT

Dry IDT Min

Wet IDT Min

3% Lime

1% Cement

4.0% Emulsion

4.5% Emulsion

2.4% Foam

2.8% Foam

1.5% Cement

100% S2 Slav. Mix

69% S2 Salv. Mix + 31% S1 Salv. RAP

In House Project

Add 3 inches of RAP treat 10 inches with 3% lime

Next day Emulsion
In House Construction (Fall of 2019)

- Add 3” RAP from stockpile
- Pretreat with 3% lime
- Treat with 4% emulsion
Two miles of 6 completed
Project winterized till spring 2020
SH 176 Odessa Nov 2018
Damage shortly after construction

Location WB 1
NM state line

Location EB 4

Location WB 3
HazMat Repair area
4 inches of HMA
Based on Design assumptions deflections should be below red line
Pavement substantially weaker than designed
Layer Moduli from Modulus7

<table>
<thead>
<tr>
<th>Adjusted Mean Moduli (ksi)</th>
<th>1399.10</th>
<th>30.89</th>
<th>0.00</th>
<th>27.48</th>
</tr>
</thead>
<tbody>
<tr>
<td>Base</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Subgrade</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Assumed Design Values

<table>
<thead>
<tr>
<th></th>
<th>70 ksi</th>
<th>30 ksi</th>
</tr>
</thead>
<tbody>
<tr>
<td>Subgrade good (similar to design assumption)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Weak base is the cause of high deflections</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Either base is wet or base is low quality</td>
<td>Probably both</td>
<td></td>
</tr>
</tbody>
</table>
Other Observations – Location 4 EB

In-situ moisture content 8.7% in flex base layer

Seal easily peeled up by hand throughout project extents
Preliminary Lab strengths on Flex Base
Item 247 Grade 1 and 2 Requires 35 psi minimum

SH 176 – 10.1% OMC & 124.0 pcf Max Dry Density

0 psi confining pressure Tx-117-E Part II (molded sample sit at room temperature inside triaxial cell for 24+/- 1 hr)

- Sample 1 Corrected stress, psi. – 11.9
- Sample 2 Corrected stress, psi. – 11.1

Conclusion  SH 176  The base is the problem
Placement of Foamed Asphalt Test Section

• 1% Cement + 3.2% Foamed Asphalt (based on lab testing)
• Placed April 30 – May 1, 2019
• Opened to traffic each evening
• One-Course placed May 2, 2019

Mix in cement, foamed asphalt, and compaction water in 1 pass operation
SH 176  1500 ft In house test section

Failed section with very poor Base  1% Cement and 2.4% Foam (PG 64-22)

High Modulus Waterproof bases with no cracking
SH 302
In middle of energy sector
ADT 50% trucks - 20 million ESAL's
6 mile long

1.5 inch of multiple seals over two flex base layers
SH 302 Odessa Deflection data

Section A (Stiff)  B (Soft)  C (Stiff)

Project with Large variation in Strength  (Different rehab for each)
Section B
Sampling and DCP Testing

Clay Contaminated base
Turns to Jello 2 ft down
## Laboratory Results

<table>
<thead>
<tr>
<th>Section</th>
<th>% Residual Emulsion</th>
<th>Cement %</th>
<th>Lab Dry* IDT (psi)</th>
<th>Lab Wet* IDT (psi)</th>
<th>Min Dry IDT (psi)</th>
<th>Min Wet IDT (psi)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A and C</td>
<td>2.4</td>
<td>1</td>
<td>94.0</td>
<td>71.4</td>
<td>50</td>
<td>30</td>
</tr>
<tr>
<td>B</td>
<td>2.4</td>
<td>1</td>
<td>51.2</td>
<td>15.3</td>
<td>50</td>
<td>30</td>
</tr>
<tr>
<td>B</td>
<td>2.4</td>
<td>1</td>
<td>52.6</td>
<td>18.9</td>
<td>50</td>
<td>30</td>
</tr>
<tr>
<td>B</td>
<td>2.4</td>
<td>2</td>
<td>67.0</td>
<td>29.7</td>
<td>50</td>
<td>30</td>
</tr>
<tr>
<td>B</td>
<td>0</td>
<td>2</td>
<td>38.8</td>
<td>26.1</td>
<td>50</td>
<td>30</td>
</tr>
<tr>
<td>B</td>
<td>0</td>
<td>4</td>
<td>46.1</td>
<td>27.8</td>
<td>50</td>
<td>30</td>
</tr>
</tbody>
</table>

* As per Special Spec  Average of 3 samples

Section A and C  **Great Results**
Section B  **Marginal** (use existing as foundation layer)
## Pavement Design Summary Sections A and C

<table>
<thead>
<tr>
<th>Superpave</th>
<th>Base Type</th>
<th>Subbase</th>
<th>Approach</th>
</tr>
</thead>
<tbody>
<tr>
<td>4 inches = 20 years time</td>
<td>8” Emulsion treat existing HMA and base (and</td>
<td>Existing</td>
<td>Widen first with flex base say 12” (two six inch thick lifts) – ensure</td>
</tr>
<tr>
<td>to first overlay</td>
<td>widened section)</td>
<td></td>
<td>lower lift is well compacted). Stabilized full width with emulsion</td>
</tr>
</tbody>
</table>

## Section B (Swamp section)

<table>
<thead>
<tr>
<th>Superpave</th>
<th>Base Type</th>
<th>Subbase</th>
<th>Approach</th>
</tr>
</thead>
<tbody>
<tr>
<td>4 inches = 17 years time</td>
<td>Add New base 8” inches thick - emulsion treat</td>
<td>Stabilize 8 inches deep full width 2% Cement</td>
<td>Widen first, cut 12 inches deep, add Geogrid, 4 inches of Bull rock and 8</td>
</tr>
<tr>
<td>to first overlay</td>
<td></td>
<td></td>
<td>inches of flexible base</td>
</tr>
<tr>
<td>4 inches = 22 years time</td>
<td>Add New base 8” inches thick - emulsion treat</td>
<td>Stabilize 8 inches deep with 2% Cement and 2.4% residual emulsion</td>
<td>Same as above</td>
</tr>
<tr>
<td>to first overlay</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

More Discussion on this section later
Conclusions

• Upfront testing is important in order to
  – Select sampling locations
  – Avoid surprises in construction
  – Part of the structural evaluation to determine if this highway is suitable for either FDR or CIR
  – Basic tests indicate what combination of stabilizers to try in the lab
  – Do not go to construction without a passing mix design