Advanced Tools for Comprehensive Evaluation of Pavement surface and subsurface conditions

Tom Scullion P.E.
Texas A&M Transportation Institute
College Station Texas

59th Annual Idaho Asphalt Conference
October 23 - 24 2019

Overview of Presentation

1. Background to TTI and TxDOT
2. Types of Non-Destructive Testing tools
3. Demonstration of PaveCheck Software
4. Use of NDT in FDR Projects
5. Use of NDT in Pavement Forensic Investigations
6. Use of NDT in Corridor Studies
7. Future Directions

1. Background to TTI and TxDOT

Texas Transportation Institute
1) Part of the College of Engineering at Texas A&M University
2) 60+ Years of research on Transportation Systems
3) Largest University-Affiliated Transportation Research Organizations in the USA
4) Major Source of Educated Transportation Professionals
5) Partners Extensively with TxDOT, other Public & Private Organizations
6) New Lab 2018 new TTI Building 2019

Flexible Pavement Program

- Research Studies
  - Balanced Mix Design for HMA
  - FDR for Energy Sector,
    - Development and implementation of new Technologies
- Interagency Agreements
  - Agency support with Forensics, Pavement Rehab
- Training Workshops
  - Seal Coats/Thin Overlays
  - FDR
  - Rubblization
  - Pavement Design
  - Nondestructive Testing
  - Intro to Paving Materials

- Manages close to 200,000 lane miles of roadway
- Does not include County or City Roads
- 2018 TxDOT Budget $13 B
  - $9 B State Roads $4 B Toll Road Construction
- For State Roads: Designs mostly done in house
- Governor and Citizens want more funding for roads
- 1000 people a day coming to Texas
- Massive construction/widening projects underway
- Energy Sector Boom (still booming)
**TxDOT Design Work**

- 25 Districts; all manage roughly 6000 to 8000 lane miles
- Each District has 3 to 4 Area Offices managed by an Area Engineer who comes up with proposed rehabilitation strategies and pavement designs
- Most work: rehabilitating – widening old roadways
- Area Offices supported by
  - District Pavement Engineer
  - Austin Divisions
  - University Researchers
  - Private Consultants (2017 on)

**NDT Air-Coupled GPR**

- Data Collection and Processing software developed by TTI
- Training schools taught by TTI
- TxDOT has 5 available units
- Data collected and processed by TxDOT
- Data collected at highway speed (60 - 70 mph)
- Effective depth of penetration 20 ins
- Measures layer thickness, locates subsurface defects and section breaks

**2. NDT Evaluation Tools**

- GPR
- FWD
- DCP
- TPAD

**Used extensively for selecting rehab options when pavement performance is poor or premature failures exist**
Successful GPR Applications

- Thickness of Pavement Layers
- Defects in Base (Wet areas)
- Defects in Hot Mix layers (stripping, trapped moisture)
- Identifying areas of segregation and poor joint density
- Deterioration in asphalt covered bridge decks
- Water filled voids under PCC
- Pavement Rehabilitation studies (identifying changes in structure)

Does not eliminate but permits smarter coring

Importance of site investigation

Falling Weight Deflectometer Testing
Deflections for Sections A, B and C

Segmenting Highways based on Strength

SH 302 in Odessa

Remaining Life and Layer Moduli

Rolling Deflectometer in Action

TxDOT’s Rolling Dynamic Deflectometer

Video camera

High-precision GPS

Electro-Hydraulic Loading System

RDD Loading Rollers

Loading Rollers and Sensors in Retracted Position

• Strength Profiling
• Joint Quality
• Void/sink hole detection
Challenges and Opportunities for FDR in Texas

- Opportunities: No shortage of candidates
- Inadequate structure for loads
- Inadequate width

Critical Steps in the FDR Process

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. Use of NDT Tools in FDR projects

- Varying pavement structure
- Construction on top of expansive clays
- Often poor existing base materials
- Early opening requirements in Energy Sector
- Need to accelerate Lab designs
- Need updated specs and design recommendations

Step 3 in the FDR Process

Sampling Equipment
- Use GPR/visual information to determine sampling locations.

4. Laboratory Mixture Design
   - Plasticity Index
   - Moisture-Density Curve
   - Binder tests (foaming)
   - Asphalt %, additive %, add rock % and foaming water %

5. Pavement Thickness Design
6. Construction Quality Control
   - Depth of pulverization
   - Gradation
   - Moisture content
   - Emulsion content
   - Foaming asphalt properties

7. Construction Quality Assurance – Density

FM 1996
Waco
Why Upfront Testing

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

Recycled 10 inches deep - Problem: locally only 7 inches of pavement over black clay

Next Foamed Asphalt job 2013

So How are we doing

• 2015 – 2018 total of 12 projects constructed using these guidelines
• Follow performance evaluations on-going
  – Visual
  – FWD survey
  – Coring (some)

Post Construction Evaluation on FM 541 San Antonio

• 1% Cement + 2.4% Foamed asphalt PG 64-22
• 4 ins add Rock + 6 ins existing
• 10 inch deep in one pass
• Open to Traffic in two hours
• 3 mile project
• 4 times faster than current undercutting design
• Backcalculated Design Modulus 303 ksi

Structural Design with FPS 21

Pavement Design Thickness
• Use Texas Flexible Pavement Design System (FPS 21) software to determine minimum FDR layer thickness
• Required backcalculated modulus for all layers (MODULUS 7)

Modulus 7 FWD Results (ETB IH 10)

Conclusions and Recommendations

• Full design needed for each project
• Do not go to construction without a passing lab design
• No failures found with approach presented
• Design modulus for future asphalt based FDR projects 220 ksi
• Monitoring continuing
5. Use of NDT Tools in Forensics Studies

Objectives of Forensic Studies
- What is the cause of the problem
- What should the TxDOT District do now
- How can the problem be avoided in the future
  - “More research is needed”
  - New Specs
  - New test procedures
  - New Equipment

Recent Forensics Studies
Case 1  Differential Widening problems
Case 2  Drainage not pavement Problems
Case 3  Damage from Truck Overloads
Case 4  Early Cracking of New Concrete

Forensics Studies and their Products
Balanced Mix Design 2004

Balanced Mix Design
Scullion/Zhou 2004

Balanced Mixes CAM 2008
TDM 2009 and SMA 2014

Sulfate Heave
Spectrophotometer
Tx Method 145E

Thermal Segregation
Pave-IR system

Case 1 Differential Widening
6 months after Construction

Road over road
**Cause of problem:** Aggregate trucks straddling joint

**Shoulder lane:** Much higher deflection in shoulder

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**Typical Section – 9ft Widening**

- **Existing Pavement:**
  - 8" CTB
  - 2-CST
  - Petromat
  - 2" CMHB-C
  - 2-CST
  - A-R Seal (New)
  - 1" Tom Mix (New)

- **New Pavement:**
  - 16" Flexbase
  - 1-CST
  - A-R Seal
  - 1" Tom Mix

**Proposed Design: 9 ft Widening on Existing Pavement**

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**New Pavement:**

- **Construction Joint – 9 ft**

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**Representative Distresses – Widened Section**

- Cement treatment of failed shoulder did not work

**Recommended Widening Typical Section**

- **Step 1:**
  - Proposed Typical Section

- **Step 2:**
  - Proposed Typical Section

- **Step 3:**
  - Proposed Typical Section

- **Step 4:**
  - Proposed Typical Section
**Case Study 2**
Frequent Repairs — what is wrong with pavement

**Site 3**
- HMA = 18-20"

**Site 4**
- HMA = 2"

Nasty clay found at all sites

**Conclusions**
- TxDOT has a very successful forensics program
- This program is a critical part of the research cycle
- Implementation includes new tools, test procedures and specifications
- We get better by learning from our problems not burying them
6. Use of NDT in Corridor Studies

**Role of TTI**

1. Research
2. Training
3. Interagency Assistance

1. Provide a 10-year Rehabilitation Plan for major corridors in Texas (Typically 100 to 200 miles long)
2. What is the cause of pavement deterioration?
3. What repairs to make (short and long term)
4. Which are the top priority sections
5. How much will it cost?

**Steps in a Typical Corridor Analysis**

- Conduct a full GPR survey of each direction of highway
- Meet with DOT personnel to:
  - Define breaks, identify problem sections or upcoming projects
  - Provide traffic estimates for each section
  - Identify their priorities and treatment preferences
- Plan and Execute an FWD and DCP test program
- Plan and Execute a field sampling program including coring to validate defects and auguring (if needed)
- Conduct laboratory testing where required (FDR, Overlay tests, etc.)
- Analyze all of the data collected
- Run Pavement Design options
- Report and Presentation of Findings

**Corridor Analysis of IH 10 in the Odessa District**

**CONTENTS**

1. Color Coded Priority Map
2. Table of Priority Projects
3. Additional Work or Modifications to Current practice
4. Section Breakdown

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Questions?