FDOT’S Experience with 3D RADAR

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Outline

• History
• Florida DOT GPR Experience
• GPR Applications
• FDOT Objectives of R06D IAP
• 3D RADAR Field Testing
• Lessons Learned
Historical Background

• Early 1980’s to Current
  – Thickness Determination (Pre-Design)
  – Density Study
  – Forensic Investigations (Sinkhole, Utilities)
  – Bridge Deck Evaluations (Rebar Depth, Deterioration Mapping)

• Equipment
  – Air-Launched GPR
  – Ground- Coupled GPR
  – Rolling Density Meter (PaveScan)
State of Florida

- 2018 Population: 20 million
  - 3rd most populous state in the US
- 94 million annual visitors
- State Highway System (FDOT Maintained)
  - 43,500 total lane miles
  - 12,000 centerline miles
Department’s Mission

• Ensure a safe transportation system
  – High Speed Non-Contact Technology
  – Support Design Initiatives
• Make data driven decisions
FDOT Goals

• Statewide Evaluation of In-service Roadways
  – Pavement Layer Thickness

• Pavement Forensic Investigations
  – Delamination/Premature Failure/Distress
  – Sinkholes/Voids
  – Utility Search
  – Buried Object Search
  – Density

• Bridge Forensic Investigations
  – Bridge Deck Deterioration Mapping
  – Bridge Rebar Cover

• Experimental Projects
  – New Materials
  – Construction Methods
FLORIDA’S GPR EXPERIENCE
FDOT Program Overview

• Based on Current GSSI GPR:
• Full Time Year Round Program
• 2,500 Lane Miles of Markings per Year (Project Level)
  – Pavement Layer thickness
• Forensic and Special Requests
  – Research, Safety, or District needs
    • Up to 50 Projects per year
Current GPR Limitations

- Single Frequency
- Limited Depth
  - Air-Launched GPR
- Not full lane coverage
- Site Specific – Ground Coupled GPR
  - Requires Maintenance of Traffic (MOT)
Sinkhole Investigation

- Pavement depression on SR 24 in Gainesville, FL
- Southbound Lanes
- Steel plate used to temporarily cover pavement depression
Bridge Deck Survey

- Bridge Number 940045
- SR A1A, Roadway Section 94060 (MP 0.330 to 0.719)
- Bridge Length = 2,054 ft.
- Bridge Width = 30 ft.
- Steel Grate from 1,314 ft. to 1,417 ft. from South End of Bridge (Excluded from Contour)
FDOT Objectives of R06D IAP

• Primary:
  – Detection of pavement delamination
  – 3D GPR Technology

• Secondary:
  – Detection of voids under concrete pavement
  – Detection of dowel bar alignment
  – Evaluation of density variations in new asphalt pavement
  – Identification and quantification of delamination in older bridge decks
  – Detection of voids over culverts, and sink holes
3D RADAR – Mounting Systems

- Mounting Systems:
  - Issues with existing mounting
  - Clutter problem not solved

GPR reflection interference (“clutter”) caused by vehicle proximity and mounting
3D RADAR – Mounting Systems

- Development of improved mounting
- FDOT: 4ft offset and 15in height
Antenna Mounting Observations

• “Clutter” is caused by reverberations from the pavement and nearby objects
• Some clutter is intrinsic to the antenna, and some is related to the mounting system and proximity to the vehicle.
• For most analyses, it will be necessary to do background removal starting just below the pavement surface, in order to effectively remove the clutter.
• Sometimes background removal takes away some of the real data
• Best approach is to mount the antenna in a way to minimize clutter
3D RADAR FIELD TEST
3D RADAR SYSTEM

- Evaluation of 17 In-service Roadways
  - Pavement
  - Bridges
3D RADAR Testing

- Testing at SMO Test Lanes:
  - Evaluation of first 150 feet of Lanes 3, 4, 5
3D RADAR Testing – FDOT SMO

- SMO Test Lane 3 – Debonding - Delamination

Lane 3 -3D Radar depth slice at 2”

North

metal tape

HVS loading location

Moisture infiltration

This section - Sand interface area (unbonded) – 1.4”
3D RADAR Testing

- SMO Test Lane 4 – Density

HVS loading locations
3D RADAR Testing

- SMO Test Lane 5 – Segregation

Lane 5 - depth slice at 1.5”

Temperature profile map
3D RADAR Testing

- Stripping and Moisture Damage
  - Interstate 10, Duval County, MP 0 – 8.989

Observed Distresses on I-10
3D Radar Testing – I-10

- Pavement consists of multiple layers
  - Friction course, 2 structural courses, ARMI layer
- Total thickness = 7 inches
- Seven cores taken at different areas
  - Four showed internal damage to the pavement structure
- Four lines of 3D Radar data were collected
  - Two in the travel lane in each direction
3D GPR Data at Core Locations on I-10

MP 6.163

Pavement surface

AC bottom layer reflection

= Areas of potential stripping

b)

b)

a)
Subsidence Study

- State 24 (Waldo Road) near Gainesville, FL
- Pavement depression experienced over the years near drainage inlet location
- FDOT 400 MHz GSSI system used initially
- Results compared to 3D Radar
- Similar comparison done for I-75 subsidence study
Subsidence Study

- 400 MHz GSSI System vs. 3D RADAR Results

Potential Shifting Soil

Potential Pipes

3D Radar
Subsidence Study – I-75

- L3 Test Location MP: 14.490 – 14.520

400 MHz

3D Radar
Subsurface Soil Stabilized Columns (SCC)

- Subsurface Soil Stabilized Columns (SCC)
  - SR 100, Putnam County, MP 7.000 – 8.000
  - Columns installed to mitigate roadway settlement

Area with installed Soil Stabilized Columns (SCC)
Subsurface Soil Stabilized Columns (SCC)

- Area with no SCC

![Diagram showing pavement surface, grout columns, bottom of AC, and bottom of SBRM.]

Gap in SCC pattern

File 010

File 012

Pavement surface

Grout columns

Bottom of AC

Bottom of SBRM
Detecting PCC under HMA

• Different types of concrete base (NB)
  – SR 5 (US 1) St. Johns County, 2-mile section, NB & SB
  – Detected location and type of concrete base
  – Identified area of extensive settlement
Detecting PCC under HMA

- SR 5 (US 1), St. Johns County, 2-mile section, NB & SB
  - Detected location and type of concrete base

55 ft. S. of Saragosa St Int.  
70 ft. S of Orange St. Int.

Different types of concrete base (NB)
Detecting PCC under HMA

JCPC Joints at 15 feet

CRCP Transverse Rebar at 6 inches
Detecting PCC under HMA

- Area of pavement settlement (SB)

170 ft. N of Orange St. Int.

62 ft. S of Saragossa St. Int.

55 ft. S. of Saragosa St Int.

Asphalt Fill

JPCP  CRCP  JPCP
Dowel Bar Detection

- SR 5 (US 1) Volusia County, MP 9.600 – 11.500 (SB)
- White-topping thicknesses – 6”, 7” and 8”
- Specially designed with different dowel patterns:
  - 12 dowels spaced at 12” centers starting at 6” from pavement edge
  - 3 dowels in each wheelpath spaced at 12” centers beginning at 12” from each edge
  - No dowels
Dowel Bar Detection

- 3D RADAR Results
Dowel Bar Detection

- Dowel Bars – Position, Dimensions and Alignment
Bridge Deck Evaluation

• SR 816 Bridge, Broward County, 3 passes per lane
• Identify spans and structural changes between spans
• Locate rebar schedules in both directions
• Calculate rebar depth and areas of deck deterioration
Bridge Deck Evaluation

- Bridge Deck – Overview Slice
Bridge Deck Evaluation

Bridge Deck – B Scan

Bridge Deck – Depth Slice, Rebar Pattern
Bridge Deck Evaluation

- **Bridge Rebar Depth**

- **Bridge Deck Deterioration Condition**
Data Analysis Software

- ExploreGPR Software processes output of Examiner
- Provides data visualization, analysis, and reporting
Lessons Learned

• Subsurface conditions revealed via data visualization using Examiner
• Need to incorporate calibration files in order to accurately compute dielectric/density
• Quantitative data analysis using post-processing software, ExploreGPR
• Looking at return on Investment (ROI)
Questions/Comments