Northeastern States Materials Engineer’s Association

Project-Level Analysis of Composite Pavements Using Ground Penetrating Radar

Online
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Agenda

- The Need
- The Device
- Case Study No. 1 – Dowels or I-Beams
- Case Study No. 2 – Deleterious Material Under Composite Pavement
- Case Study No. 3 – Voids Under Composite Pavement
- Recommendations on Practice
- On-Going Studies
The Need

• Ground-Penetrating RADAR has been around many decades
  – Improvements to use of ‘off the shelf’ equipment
  – Improvement to resolution at shallow depths
• Composite Pavements have unknown condition without costly excavation or
The Need

• Can we push the limits of resolution/technology to reduce need for open excavations
• Can off-the-shelf solutions provide in-the-field answers to subsurface uncertainties
The Device

• Ground-Penetrating RADAR
  – RAdio Detection And Ranging
• Generate wide-frequency pulse, interpret difference in waves as they return to the device.
• Applications in roadways back many decades, however technologic limits existed on data collection rate and frequency of antenna.
The Device

- Case Study No. 1 & 3 Utilized
  - 1.6 GHz (No. 1 only)
  - 2.6 GHz
- Ground-coupled, analog antennas
- 2mm scan spacing/0.0174 nano-seconds
The Device

• Case Study No. 2 Utilized
  – 2.6 GHz
• Ground-coupled, analog, all-in-one concrete scanning device
The Device

• Adapting a 3D Concrete Survey to Composite Pavements (Adding a layer to penetrate and interpret)

Photo Source: GSSI
The Device

- Lower frequencies ➔ deeper penetration, but limited clarity at shallow depths
- Higher frequencies ➔ shallower penetration, but higher clarity
- Ground-Coupled systems are slower to use
  - can’t operate at highway speed
  - preserve energy lost at air/surface interface
Case Study No. 1: Differentiate Load Transfer Devices

- For a period of time, CT DOT permitted the use of i-beam style load transfer devices (LTDs) on Jointed Concrete pavements.
- It is unknown where these load transfer devices remain across the state, but the state desires to replace with modern dowels when encountered.
Case Study No. 1: Differentiate Load Transfer Devices

- Pseudo-Spectral Time Domain simulation performed to determine whether dowels vs. i-beams may be differentiated.


https://doi.org/10.1190/gpr2020-049.1
Case Study No. 1: Differentiate Load Transfer Devices

- Success!
- Field-confirmed
  - length of LTDs
  - spacing of LTDs
  - structure layer thicknesses
- Hypothesize we did encounter i-beam LTDs at some locations
Case Study No. 2: Deleterious Material on Rubbleized PCC

- 7-9 inches HMA over PCC in design
- 2.6 GHz all-in-one Ground-Coupled GPR unit
- Surface Distresses prompted investigation
Case Study No. 2: Deleterious Material on Rubbleized PCC
Case Study No. 2: Deleterious Material on Rubbleized PCC

- Asphalt layer found to be thicker than original design
- ‘Pasty’ Effluent and light colored material indicative of a deleterious patch material
In the field, wavy subgrade signals from GPR seemed to relate to presence of patch material.
Case Study No. 2: Deleterious Material on Rubbleized PCC

- Performed analysis of Traffic-Speed Survey Devices (ARAN + iPAVE) to identify potential other sites
Case Study No. 3: Voids Under Composite Pavement

- Air-Couple GPR identified location void to be field-verified with Deflectometer Testing prior to repair
- Deflectometer indicated no repair necessary
- 2.6GHz Ground-Coupled brought in to see which NDT method it aligned with
- Attempted On-board 3D scanning software from Controller
Case Study No. 3: Voids Under Composite Pavement

- Laid out a 1-ft grid
- Longitudinal + Transverse
Case Study No. 3: Voids Under Composite Pavement

- Screen shots from field analysis: Panel 1
  - Seems like voids may exist
  - Unable to core/excavate to confirm
  - Asphalt layer seen to thicken (perhaps for a super elevation)
Case Study No. 3: Voids Under Composite Pavement

- Screen shots from field analysis: Panel 2
  - No visible ‘deformations’ of signal across the panel
- Moisture plays a role in reading reflections/scans
3D Scan

Playback Mode - I91SB - GRID_002

Total # of lines: 33 (26 X, 7 Y)
Estimated Size 4 MB

Slice Depth 0.00 ft
Slice Thickness 0.15 ft x 2

(6.0ft, 25.0ft)

View Toggle 19 Gain Fence Y H Cursor 48 Rotate Output
3D Scan

Playback Mode - I91SB - GRID_002

Total # of lines: 33 (26 X, 7 Y)
Estimated Size 4 MB

Slice Depth 0.15 ft
Slice Thickness 0.15 ft x 2
3D Scan

Playback Mode - I91SB - GRID_002

Total # of lines: 33 (26 X, 7 Y)
Estimated Size 4 MB

Slice Depth 0.30 ft
Slice Thickness 0.15 ft x 2
3D Scan

Playback Mode - I91SB - GRID_002

Total # of lines: 33 (26 X, 7 Y)
Estimated Size 4 MB

Slice Depth 0.51 ft
Slice Thickness 0.15 ft x 2
3D Scan

Playback Mode - I91SB - GRID_002

Total # of lines: 33 (26 X, 7 Y)
Estimated Size 4 MB

Slice Depth 0.60 ft
Slice Thickness 0.15 ft x 2

(6.0 ft, 25.0 ft)
3D Scan

Playback Mode - I91SB - GRID_002

Total # of lines: 33 (26 X, 7 Y)
Estimated Size 4 MB

Slice Depth 0.72 ft
Slice Thickness 0.15 ft x 2
3D Scan

Playback Mode - I91SB - GRID_002

Total # of lines: 33 (26 X, 7 Y)
Estimated Size 4 MB

Slice Depth 0.81 ft
Slice Thickness 0.15 ft x 2
3D Scan

Playback Mode - J91SB - GRID_002

Total # of lines: 33 (26 X, 7 Y)
Estimated Size 4 MB

Slice Depth 0.90 ft
Slice Thickness 0.15 ft x 2

(6.0ft, 25.0ft)
3D Scan

Playback Mode - I91SB - GRID_002

Total # of lines: 33 (26 X, 7 Y)
Estimated Size 4 MB

Slice Depth 1.02 ft
Slice Thickness 0.15 ft x 2

(6.0ft, 25.0ft)
3D Scan

Playback Mode - I91SB - GRID_002

Total # of lines: 33 (26 X, 7 Y)
Estimated Size 4 MB

Slice Depth 1.11 ft
Slice Thickness 0.15 ft x 2

(6.0ft, 25.0ft)
3D Scan
Total # of lines: 33 (26 X, 7 Y)
Estimated Size 4 MB

Slice Depth 1.32 ft
Slice Thickness 0.15 ft x 2

(6.0 ft, 25.0 ft)
3D Scan

Playback Mode - I91SB - GRID_002

Total # of lines: 33 (26 X, 7 Y)
Estimated Size 4 MB

Slice Depth 1.4 ft
Slice Thickness 0.15 ft x 2

(6.0ft, 25.0ft)

View Toggle 19 Gain Fence Y H Cursor 48 Rotate Output
3D Scan

Playback Mode - I91SB - GRID_002

Total # of lines: 33 (26 X, 7 Y)
Estimated Size: 4 MB

Slice Depth: 1.50 ft
Slice Thickness: 0.15 ft x 2
Recommendations + Improvements

- Lessons Learned Moving Forward & Future Tasks
  - Longitudinal Scans Only for void detection
  - Run 0.5 ft interval
  - Run Normal + Cross-Polarized Scans to boost clarity in presence of welded wire
  - Build laboratory mock-ups of known composite conditions
  - Truck-Mounted Scanning for longer/faster Collection
  - Ground truthing dielectric for core/scan pairings in CT

Photo Source: GSSI
Current Studies: Pushing the limits

- Can we detect inter-asphalt layer differentials?
- Scans performed in the vicinity of a sand/skim layer
- Cores and test-pits performed as well
- Currently analyzing GPR data for possible identification
- Challenge: Sensitivity of the equipment to detect change in resistivity between different densities of material and accounting for noise of measurement
Questions?

Thank You!

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