Ground Penetrating Radar (GPR) for Pavement Condition Evaluation

by

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Presentation Outline

- Background
- GPR Equipment and Software
- Pavement Applications
- Future Prospects
What is GPR?

- Transmits pulsed radio waves through pavement materials
- Waves reflect at material boundaries
- Arrival time and strength of reflections determine material depths, thicknesses, and properties
What does GPR Detect?

- Thickness of pavement layers
- Reinforcing steel
- Density variations
- Subsurface moisture
- Voids
Evolution of GPR

• 1960’s, 70’s - early development
  – Military applications
  – Tunnel and mine detection
• 1980’s - Initial adaptation to highways
• 1990’s - Practical development and implementation for pavements
• 2000+ - Adaptation by highway agencies
GPR Equipment

- Data acquisition and control systems
- GPR antennas
  - Air Coupled
  - Ground Coupled
1 GHz Horn Antennas
Current Horn Antennas

1 GHz Horns

2 GHz Horns
Ground-Coupled Antennas

1.5 GHz  500 MHz
Equipment Summary

- Antennas have become more compact
- Electronics have become more stable
- Range of frequencies has expanded
  - Provides higher resolutions, greater depths of penetration
Software and Data Interpretation
Principles of GPR Application

Measurement Setup

- Antenna
- Air
- Asphalt
- Base
- Subgrade

GPR Record

Volts

Time

1
2
3
Sample of Data

Pavement Structure

Asphalt Layers

Base Layers

GPR Record

Time (ns)

$T_a$

$T_b$
Sample Graphic GPR Data

Distance

Pavement Surface

Asphalt

Base

Time/depth
Sample Processed Graphic Data on Asphalt Pavement

Pavement Surface

Asphalt

Base
Linear Plot of Pavement Layer Thickness

Mile Marker

Depth (in)

Cores
Asphalt Layers
Base Layer
GPR Data for PCC Pavement

Bottom of PCC
Bottom of Base
Joints
Typical Pavement Structure Data Analysis

Bottom of Base

Bottom of AC
GPR Data with Unclear Interpretation
Software/Interpretation

- Software developments have facilitated quantitative analysis
- Some interpretation is still required to distinguish layer types
- Fully automated processing is available for limited applications (density, FWD)
Pavement Applications
Pavement Applications of GPR

• Pavement Management (Network)
• Rehabilitation Design (Project)
• Quality Assurance of New Pavement Construction (thickness, density)
• Subsurface Moisture/Drainage
• Location of Dowels
• Detection of Asphalt Stripping
GPR for Pavement Management

- Layer structure data for PMS
- Layer thickness for network FWD
- 100-200 lane miles per day coverage
- Results typically at 0.1 mile intervals
Rehabilitation Design

- Existing thickness for overlay design
- Bound layer thickness for design of in place recycling depths
- Thickness used with FWD data
- Locate areas of high moisture for drainage design
- Locate subsurface damage
Accelerated Rutting from Clogged Drains
View of Clogged Drain
Detection of Drain with GPR
Base Moisture Content from GPR
Future Prospects for GPR

- **Equipment**
  - More compact, portable (wireless) equipment
  - Implementation of antenna arrays
  - Increased frequency range for depth/detail
- **Software**
  - more automated, user friendly
- **Applications**
  - Improved detection capability for expanded applications