North Dakota County Roads - Pavement Network Structural Assessment: Integration of GPR and FWD Data

by

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Background

• ND State Legislature Commissioned Study
• Assess 20-year transportation Infrastructure Needs
  – County, townships, tribal roads
• Motivated by
  – Oil related traffic
  – Agricultural related traffic
Background

• 2010 study: UGPTI estimated road investment needs for the 2011 session
  – Based on 21,500 new wells
• 2012 study: updated road investment needs for the 2013 session
  – Based on 46,000 new wells
• Current study: updated estimates based on higher forecasts (e.g., 60,000 new wells)
Pavement Data Collection

• Ride and Distress Data – 4786 miles
• Falling Weight Deflectometer (FWD) and Ground Penetrating Radar (GPR) – 1519 miles
  – Western ND (785 mi)
  – Eastern ND (734 mi)
Nondestructive Testing - Statewide
FWD/GPR Testing Equipment

Dynatest Model 8002 FWD

GSSI 1-GHz Horn Antenna
GPR System
FWD/GPR Testing

• Testing period: 08/05 through 9/21/2013
• GPR/FWD collected independently
  – Coordinated using GPS
• Numbers:
  – Number of segments: 169
  – GPR data collected continuously at 1 foot intervals
  – Number of FWD test locations: 6,259
  – FWD used two load levels and two replicates
  – 21,560 deflection basins collected
### Sample GPR Output

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Backcalculation

- **Software:** ELMOD (Dynatest)
- **Assumptions:**
  - Linear elastic moduli for HMA and unbound base layers
  - Non-linear elastic modulus for subgrade
  - Thicknesses from GPR
  - All structures were limited to max 3 layers
Iterative FWD and GPR analysis

- GPR layer interpretation checks done through the backcalculation
- Modulus reasonable checks applied
- Layer type interpretation updated iteratively
- Result improve the overall quality and accuracy of both analyzes
Impact of Iterative Technique

First  Second  Final

Analysis Iteration

Deflection Basins with Unreasonable Backcalculated Layer Moduli (%)
Results - HMA

Backcalculated Surface Layer Modulus (ksi) at Reference Temperature of 77°F
Results – Unbound Base Layer

Frequency of Observations

Backcalculated Base Layer Modulus (ksi)

0% 20% 40% 60% 80% 100% 120%

0 500 1000 1500 2000 2500 3000 3500

Frequency
Cumulative %
Results - Subgrade

Frequency of Observations

Backcalculated Subgrade Layer Modulus (ksi)

Frequency
Cumulative %
Analysis Steps & Review

• FWD/GPR Structure Information used with AASHTO 1993 Design Guide
• Year & type of improvement predicted.
• Improvement threshold: PSR < 2.5
• Year of improvement based on:
  – Existing structural capacity
  – Forecasted ESALs
Summary

- GPR/FWD combination effectively provides pavement structure data at network level
- Results can be used to predict remaining life and project required improvements
- North Dakota was able to use this approach to evaluate its 20 year transportation infrastructure needs.