Implementation of the Traffic Speed Deflectometer (TSD) for Network Level Pavement Management

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Background

• Current PMS are based on surface distress
  - Continuous distress survey systems are available
• Remaining life depends on roadway structure
  - Below the surface
• TSD can now provide continuous roadway deflection data
  - Over 200 miles per day/no closures
• GPR provides continuous layer structure data
• Combination can produce layer mechanical properties for roadway structural analysis
Idaho Pilot Project

• Develop a more effective strategy for project selection and design
• Use TSD deflection data with GPR layer thickness data to calculate pavement structure properties
• Publish the data as a geospatial database usable to a wide audience
• Demonstrate the use of the data at both network and project levels
Pilot Project – Idaho District 6
2015 - 2017

1035 total miles of roadway
168 miles Interstate
867 miles primary roads
Data Collection

- TSD continuous at 10m and 0.01 mi. intervals
  - Provides deflection slope at various offsets from load
- FWD data in select areas for comparison
- Ground Penetrating Radar (GPR)
  - 1 GHz Horn Antenna, continuous at 1 foot intervals
- Selective coring for layer structure clarification
Raw TSD Measurements

Deflection Slope = \( \frac{V_v}{V_H} \)

*not to scale*
GPR Thickness Data Analysis
Data Analysis Calculations

1. Deflections (from TSD slopes)
2. Layer Thickness (GPR)
3. Layer Moduli (steps 1+ 2 using Evercalc)
4. Effective Structural Number (2 + 3)
5. Required Structural Number for 20-year life (3 + W_{18})
6. Required Overlay Thickness (from 5)
7. Remaining Service Life (from 3, 4, and W_{18})
TSD vs. FWD – Maximum Deflection (D0)

Deflection (mils)

Station (m)

TSD 0 Meter Sensor
FWD 0 Inch Sensor
TSD vs. FWD – Subgrade Modulus ($M_R$)

![Graph showing subgrade modulus comparison between TSD and FWD at various stations (m).]
Segmentation and Remaining Life (SH 28)
Roadway Structure GeoDatabase

• Data is recorded in a series of tables
• Data is displayed spatially using ArcGIS
• Database is accessible through iPLAN
  • [Link](http://iplan.maps.arcgis.com/apps/webappviewer/index.html?id=8099d313c7ac45119d44af98eeb98dfe)
Segmented Remaining Life (years)
Segmented Remaining Life (years)
US-28 Project-Level Segment Analysis

Remaining Life
US-28 Project-Level Segment Analysis

Remaining Life

Structural Number
US-28 Project-Level Segment Analysis

Remaining Life

Structural Number

Subgrade Modulus, $M_r$
Use of Structure Data in Pavement Management

• Incorporate Data into PMS database
  - (ITD TAMS uses Agile Assets)

• Decision Rules - Add structure parameters to supplement surface distress

• Performance Curves - modify existing curves using structure data
Typical PMS Decision Rule

• Distress index based on fatigue cracking, patching, and edge cracking

Flexible Distress Index (DI) Decision Tree

- **DI < 25**  
  Treatment = Reconstruction

- **25 <= DI < 40**  
  Treatment = Rehabilitation

- **40 <= DI < 60**  
  Treatment = Restoration

- **60 <= DI < 75**  
  Treatment = Resurfacing

- **DI > 75**  
  Treatment = No treatment
Add Structural Capacity Decision Tree

- Add Decision Rules based on Required Overlay Thickness (OL) and subgrade modulus Mr
TSD Roadway Structure Data in PMS

- Standard Performance Curves

![Flexible Pavement Performance Models](image-url)
TSD Roadway Structure Data in PMS

• Modified Performance Curves
Life-Cycle Simulation for 217 Segments

• Evaluate decisions and resource allocation
  1. Treatment options using surface distress only
  2. Treatment options adding structure data to the treatment decision trees

• Compare the two over a 50-year life cycle

• Examine the benefit
Life Cycle Modeling per Pavement Segment
50 year ‘Network’ Life Cycle Results
217 sections (735 miles) analyzed

**Benefit**
- Est. Cost Savings Using Structure Data: $15,572,100
- $15,572,100/735 miles = $21,186/mile over 50 years

**Cost/Benefit**
- If ITD collects this data every 5 years, then:
  - $21,186/10 = $2,118/mile per rating cycle in savings
- Assume data collection cost is $300/mile
- Return on Investment (ROI) = $2,118/$300 = ~7
Summary of TSD + GPR

• Combination of TSD and GPR has been demonstrated for determining network-level roadway structure data
• Process has been completed on over 1000 miles of roadway
• Resulting data is available via a statewide geodatabase
• Results support network overview and project planning
• Use of results in PMS can produce significant cost savings
• These results will be extended statewide using additional TSD data provided by the pooled fund study