Goals of Presentation

- Describe tools & techniques for pavement evaluation
- Help highway designers select appropriate ones

Surface Evaluation
- Conventional approaches
- Innovative approaches

Subsurface Evaluation
- Destructive – conventional cores & borings
- Non-Destructive- deflection testing, ground penetrating radar, other specialized tools
Tools and Techniques for Pavement Evaluation

Paul Wilke, P.E.
ASHE Harrisburg Section Meeting
March, 2012
Goals of Pavement Evaluation

- Quantify pavement conditions and uniformity/variability
- Identify causes of distresses
- Estimate remaining pavement life
- Provide parameters needed to identify (and design) feasible rehab alternatives
- Should only collect data that will be used for decision making!
Components of Pavement Investigation

**Surface conditions**
- Evaluation of visible distresses
- Evaluation of other features (roughness, skid resistance)

**Subsurface conditions**
- Pavement composition & thickness
- Condition of pavement layers
- Soil types and strength
Surface Condition Survey
(Windshield Survey)

- Overall subjective assessment

- Segments of variable condition may not be apparent
Surface Condition Survey (Detailed Distress Mapping)

Most useful when detailing specific “spot repairs”
- Eg- Concrete pavement restoration
- Dowel bar retrofits, full depth patches, etc

Can be “information overload”
- How will you make rehab decisions from the distress map?
Surface Condition Survey
Pavement Condition Index (PCI) Approach

- Intermediate between 2 extremes

- Useful in identifying segments of variable condition
  - Developing more than rehab treatment
Condition Survey (PCI Approach)

- Project divided into sections (segments)
  - Consider pavement history
  - Typically uniform segment lengths

- Type, quantity & severity of distresses measured (or estimated)
  - Can be used for repair quantities

- Calculation of overall condition index can be useful
  - Helps identify variability between segments
Options for PCI- Type Surveys

Foot on ground (FOG)survey

- Automated collection of high resolution downward facing pavement images
- Manual distress rating in office

Semi-automated - Digital Survey Vehicle (DSV)

- Automated collection of high resolution downward facing pavement images
- Manual distress rating in office
Digital Survey Vehicle

Data Collected

- Digital Video Pavement Images
- Multiple Digital Video Right-of-Way Images
- Longitudinal Profile/Roughness
- Rutting
- Faulting
- Cross-slope & Grade
- Macro-Texture
- Linear Distance
- GPS Coordinates
DSV Survey Systems
I-95 DSV Condition Survey

High resolution downward pavement images viewed with customized software
Comparison of Condition Survey Methods

DSV vs FOG Methods

- Similar end result
- DSV faster & safer for field data collection
- DSV typically more accurate (unless physical measurements made with FOG)
- DSV provides geo-referenced images for other uses
- DSV provides roughness, rutting, faulting & cross-slope measurements
- FOG costs less for small projects with low traffic volume
Example of Condition Survey Data & Uses (I-95 New England Thruway)

- 84 lane-miles; 140,000 AADT; 12% trucks

- Two different pavement design sections

- Variable pavement conditions

- Two phase project
  - Preliminary design - pavement investigation; identify rehab treatment(s) and cost
  - Final Design - contract documents (including detailed repair plan & details)
High Traffic Volume Precluded FOG Survey
DSV Survey Performed
Example Distress Rating
Forward Images Provided

- Right of Way Cameras not used for collection of roadside assets
- Very useful to transportation design firm
- Specialized software not required to view images

Southbound MP 4.372
Sampling of Forward Images
I-95 Pavement Data

Phase I complete:
- Summarized data multiple ways to aid in evaluations by segment
- More than one rehab treatment identified
- Repairs types & quantity assigned by distress type & severity
- Used for quantities in preliminary costs

Phase II underway:
- Detailed repair maps for concrete pavement repairs
Distress Quantity & Severity Summary

Distress Summary NB Left Lane MP 0.17 to MP 6.72

Legend:
- AC_S - Asphalt Section Start
- AC_E - Asphalt Section End
- CB - Corner Breaks
- CS - Corner Spalls
- JS - Joint Spall
- L-AC - Large Patch (AC)
- S-AC - Small Patch (AC)
- L-PCC - Large Patch (PCC)
- S-PCC - Small Patch (PCC)
- OES - Cracked Slabs
- DS - Divided Slab
- STC - Stretched Transverse Cracks

Number of Slabs

- 0.170 To 1.00
  - 99 Slabs
- 1.00 To 2.00
  - 113 Slabs
- 2.00 To 2.83
  - 52 Slabs
- 2.33 To 2.55
- 2.55 To 3.00
  - 53 Slabs
- 3.00 To 4.00
  - 123 Slabs
- 4.00 To 5.00
  - 92 Slabs
- 5.00 To 6.00
  - 80 Slabs
- 6.00 To 6.72
  - 96 Slabs
IRI (0.1 mile averages)

NB Left Lane - Average IRI
Average PCI by Segment

Northbound Center Lane PCI from MP 0.17 to MP 14.10
# CONDITION INDEX (PCI) SUMMARY

## Northbound

<table>
<thead>
<tr>
<th>Condition Category</th>
<th>MP Range</th>
<th>Pvmnt Age</th>
<th>Joint Spacing</th>
<th>PCI Left</th>
<th>PCI Center</th>
<th>PCI Right</th>
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## Southbound

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<td>△ 56.3</td>
<td>△ 59.5</td>
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<td>△ 93</td>
<td>△ 86</td>
<td>△ 90.8</td>
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<td><strong>PCC (18' Jts)</strong></td>
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<td></td>
<td>△</td>
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</tr>
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</table>

**AC Overlay**

- **Pavement Condition Index (PCI) ≥ 71** is Good/Satisfactory
- **56 ≤ PCI ≤ 70** is Fair
- **PCI ≤ 55** is Poor

* age 27 except 2.50-2.85= 19 yrs
2nd Example: PennDOT I-81 (Lebanon County)

- Simpler investigation
- Thin HMA overlay covering concrete
- Survey focus - joints & patches
- Used DSV to collect data safely
## Distress Quantity Summary

### I-81 Southbound Passing Lane

<table>
<thead>
<tr>
<th>Mile Post</th>
<th>Distress</th>
<th>Distress Code</th>
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<td>Patch - LJ</td>
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<td>Patching (TJ)</td>
<td>Patch - TJ</td>
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<td>Patching (Other)</td>
<td>Patch -O</td>
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<td>97.0 To 97.5</td>
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<td>Patching (Other)</td>
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</table>
Comparison of Condition Surveys (I-95 & I-81)

- Not all projects require the same level of detail.
- PCI is very useful for I-95 in identifying segments of similar condition.
- PCI would not have been useful for I-81.
- Not necessary to quantify all distresses for I-81.
- Windshield survey would have had significant limitations for I-95 or I-81 (more quantitative data helped decision making).
That’s it for the DSV & Condition Surveys
Skid Resistance (Friction)

- Locked Wheel Skid Resistance Testing (ASTM E-274)
- Smooth (ASTM E-524) and/or Ribbed (ASTM E-501) Test Tire
- Measures friction under flooded conditions
- Tests performed at 40 MPH
- Data reported as SN or FN
Subsurface Pavement Investigation

Destructive Testing

- Conventional cores & borings
- Cone Penetrometer Testing (CPT)
Subsurface Investigation
Non-Destructive Testing

Falling Weight Deflectometer (FWD)
- Structural evaluation

Ground Penetrating Radar (GPR)
- Layer thickness
- Other applications
Falling Weight Deflectometer (FWD)
FWD Schematic

- Weight dropped on load plate
- Deflection measured at series of sensors
Uses of FWD

- Evaluate variability of overall pavement strength
- Determine “strategic” core & boring locations
- Determine subgrade soil strength
- Structural adequacy & remaining life
- Provides parameters for overlay design
- Void location (concrete pavements)
- Joint load transfer (concrete pavements)
Average Structural Capacity

SC

Section 1

Section 2

Distance
Example FWD Test Results

Maximum Deflection Normalized to 9000 and 70 °F
Example FWD Test Results

Subgrade Resilient Modulus

<table>
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<tr>
<th>Station</th>
<th>Lane 1</th>
<th>Lane 2</th>
<th>Lane 3</th>
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<td>30000</td>
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Resilient modulus, psi

Resilient modulus, MPa

Station
Example FWD Test Results

Effective Structural Number

Station

Structural number, m

{Graph showing structural number vs. station for different lanes}

Lane 1
Lane 2
Lane 3
Lane 1
Lane 2
Joint Load Transfer Evaluation

- Evaluate efficiency of load transfer across joint or crack
- Useful data for evaluating feasible rehab treatments
Deflection Testing
Rigid Pavements

\[ \Delta = 0.66 \text{ mm} \quad \text{(loaded)} \]
\[ \Delta = 0 \text{ mm} \quad \text{(unloaded)} \]

0% Load transfer

\[ \Delta = 0.33 \text{ mm} \quad \text{(loaded)} \]
\[ \Delta = 0.33 \text{ mm} \quad \text{(unloaded)} \]

100% Load transfer
## FWD Load Transfer Efficiency (Sample Data)

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<th>D3</th>
<th>D9</th>
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</table>
# Combined Distress & FWD Data

(To Estimate Patching)

## Summarized Estimated Pavement Patching Quantities

<table>
<thead>
<tr>
<th>SR-81</th>
<th>MP 96.7 to 104.0</th>
<th>FWD Fail %</th>
<th>Pavement Patching (SF)</th>
<th>Total Lane Area (SF)</th>
<th>% of Lane Patching</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Direction</strong></td>
<td><strong>Lane</strong></td>
<td><strong>TC (M)</strong></td>
<td><strong>TC (H)</strong></td>
<td><strong>%</strong></td>
<td><strong>Area</strong></td>
</tr>
<tr>
<td>NB Travel</td>
<td>451</td>
<td>69</td>
<td>75</td>
<td>28,080</td>
<td>462,528</td>
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<td>54</td>
<td>79</td>
<td>38,280</td>
<td>462,528</td>
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<tr>
<td>NB Passing</td>
<td>434</td>
<td>13</td>
<td>41</td>
<td>13,195</td>
<td>462,528</td>
</tr>
<tr>
<td>SB Passing</td>
<td>479</td>
<td>68</td>
<td>71</td>
<td>27,963</td>
<td>462,528</td>
</tr>
</tbody>
</table>

**TOTAL** 107,518 1,850,112 5.8%

TC(M) = Number of Moderate Severity Transverse Cracks rated from images.

TC(H) = Number of High Severity Transverse Cracks rated from images.

Pavt Patching (SF) = (TC(M) + TC(H)) x (FWD Fail%) x (6 x 12)

Total Lane Area (SF) = (104-96.7) x 5280 x 12
Ground Penetrating Radar

Aerial Antennas

Ground Coupled Antennas
(portable unit)
Asphalt Thicknesses

Determining areas of varying asphalt thickness
GPR – Granular Thickness
Concealed Repair Patches
Magnetic Imaging Tools

Magnetic imaging tools emit and detect magnetic fields

Any metallic objects within proximity of the scan unit are identified and can be measured

Applications include:
- Measuring lift thickness (MIT Scan-T)
- Spatial location of dowel bars (MIT Scan 2)
MIT Scan-T (Pavement Thickness)
MIT Scan- Dowel Bar Alignment

Construction Acceptance Testing
➢ Often required if automated dowel bar inserter

Forensic Evaluations:
Other Unique Tools

Cover if time permits
Rolling Wheel Deflectometer

- FWD concept applied to tractor trailer
- Continuous deflection measured by laser
- Less accurate (useful at network level)

Reference beam and forward lasers

Laser between dual tires
Rolling Weight Deflectometer

Distance = 8 ft

Deflection is difference between deflected and undeflected surfaces (i.e., $D_2 - C_1$)
Pavement Noise Measurement

SPONSOR: Illinois State Toll Highway Association (ISTHA)

OBJECTIVES:

- Compare the noise characteristics of 5 HMA test sections
- Collect and analyze sound intensity data as the in-service pavements age

DELIVERABLE:
- Engineering report summarizing relative and time dependant noise characteristics of the five HMA test sections.
Equipment on Display

- Digital Survey Van
- Falling Weight Deflectometer

Check out equipment on your way out.....
QUESTIONS???