Development of a High-Speed Rolling Wheel Deflectometer

Southeastern States Pavement Conference
Louisville, Kentucky
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Outline

- Role of the RWD
- SBIR Research Objective
- Research Accomplishments
- Summary of RWD
  - Deflection Measurement Concept
  - Field Trial Results
- Texas Demonstration and Evaluation
- Deployment of Technology
- Benefits of RWD
Role of the RWD (1 of 2)

Bridge management system

Overall asset management system

Pavement management system

Sign management system

Other asset management system
Role of the RWD (2 of 2)

Current condition through Pavement system management and high-speed collection methods available currently requires traffic control.

High-speed collection methods available currently requires traffic control.

Condition (cracking) | Ride quality | Rutting

Asset management system

Pavement management system

Pavement management decision-making process

Load-carrying capacity
SBIR Research Objective

SBIR Contract DTRS-57-95-C-00102 to Applied Research Associates, Inc. in 1996 to:

“Develop a rolling wheel deflectometer (RWD) that meets the pavement structural assessment needs of pavement managers”

- Actual moving truck load
- Highway speeds up to 55 mph
- Continuous deflection measurements
- Network-level PMS applications
SBIR Accomplishments

- Time frame 1996 – 2002
- Phase I
  - Assessment of technology
  - Developed specifications for RWD
  - Options for Structural Index
- Phase II (Part 1)
  - Designed and fabricated RWD trailer
  - Installed scanning laser
  - Developed software for data collection and processing
  - Initial proof of concept tests (not successful)
Phase II (Part 2) - Amendments to SBIR contract
- 4-spot lasers (16 kHz Selcom SLS-5000) mounted on rigid beam
- Spatially coincident approach (not entirely successful in the past)
- Improved data acquisition and processing
- Sampling rate – sample every 0.48 inch at 55 mph

Proof of concept was successful in July 2002

Current system collects a single point average deflection on flexible pavements along tangent roadway segments
RWD Deflection Measurement

- 4 lasers mounted at 8-ft intervals
- Lasers A, B, and C measure undeflected surface
- Laser D measures deflected surface near load wheel
- Compare readings after each 8-ft of travel

Deflection is difference between deflected and undeflected surfaces (i.e., $D_2 - C_1$)
Photos of RWD Components

- RWD Trailer and Laser Beam
- Laser D in Front of Wheels
- Data Acquisition and Controls
- Water Calibration Set-up
Proof of Concept Field Trials

- Field Testing Site
  - Field trials conducted in July 2002 on Staley Road near Champaign, Illinois
  - Thick and thin AC pavement sections tested

- Testing Details
  - Multiple runs at speeds from 30 to 55 mph
  - RWD deflection measurements were average over 500-ft runs
  - Reference accelerometer installed in pavement
  - FWD deflections for comparisons
Comparison to Reference Sensor

Thick AC

**Deflection, mils**

<table>
<thead>
<tr>
<th>Time of day</th>
<th>10 AM</th>
<th>12 PM</th>
<th>2 PM</th>
<th>4 PM</th>
<th>6 PM</th>
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<tbody>
<tr>
<td>RWD</td>
<td></td>
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<tr>
<td>Accelerometer</td>
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</table>
Comparison to Reference Sensor

Thin AC

Deflection, mils

Time of day

RWD
Accelerometer
Summary of Deflection Results

Proof of Concept Results

Mean Deflection, mils

<table>
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<tr>
<th></th>
<th>RWD</th>
<th>Accel</th>
<th>FWD*</th>
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<tbody>
<tr>
<td>Thick AC</td>
<td>11.1</td>
<td>10.3</td>
<td>8.7</td>
</tr>
<tr>
<td>Thin AC</td>
<td>12.8</td>
<td>13.3</td>
<td>14.0</td>
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*Tested on different date
Demonstration and Evaluation

- Field Evaluation of RWD Capability
  - July 14 – 25, 2003
  - Near College Station, Texas
  - Funded by FHWA and Texas DOT

- Issues Included in Field Tests
  - Section Length for Data Processing (<500 ft?)
  - Pavement Factors To Be Considered
    - Surface Texture
    - Curves and Grades
    - Pavement Strength (deflection ranges from 5 to 35 mils)
    - Rutted Surface
  - Effect of Data Collection Speed
  - Comparisons to FWD, Texas RDD, and MDD
  - Repeatability

- Improvements Needed for Deployment
  - Sensors
    - Improved laser calibration
    - Additional sensors
  - Controls, data acquisition, and data processing
    - Move data acquisition to truck cab
    - Add automated data collection and processing
    - Add automated adjustment for temperature
    - On-board GPS
  - Other hardware and software changes

- Deployment Demonstrations
  - Five states to be selected by FHWA
  - Format determined by FHWA and participating states
Future Development (2005-2010)

- Long-term plan for further improvements to prototype and completion of full production unit

- Enhancements include:
  - Addition of Doppler lasers with current spot lasers to provide capability for:
    - Testing rigid pavements including load transfer efficiency of joints between slabs
    - Measuring complete deflection basin to provide structural analysis of pavements (FWD replacement)
  - Fully automated data acquisition and processing
  - Addition of GPR, GPS, and other support technologies

- Project level and network level applications
Ultimate Benefits of RWD

- Nondestructive method for measuring the structural capabilities of a pavement network
  - Minimal disruption to highway traffic flow
  - Safe operations
  - Full deflection basin

- Real time assessment of remaining structural life of the nation’s highway system

- Information for managing pavements:
  - Improved decision-making processes for preserving pavements (better asset management)
  - More accurate estimates of our Nation’s highway funding needs