Laser-Based Technology for Automated Rut Measurement in Accelerated Pavement Testing

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Overview

- Florida’s APT program
- Pavement profile measurements
- Implementation of non-contact profiling in APT
- Data collection and analysis functions
- Automated rut measurements
- Other applications
FDOT’s APT Program

- Initiated in Year 2000
- To date:
  - 2 flexible pavement experiments
  - 1 rigid pavement experiment
  - 1 composite pavement experiment
  - 2 geotechnical experiments
  - 1 miscellaneous experiment – Raised pavement markers
Heavy Vehicle Simulator (HVS)

- Diesel or Electric Power
- Weight: 50+ t, Length: 23 m
- Height: 4 m, Width: 3.7m
- Loading: 31 – 200 kN
- Wheel speed: 15 kph
- Maximum Passes per day:
  - 29,000 bi-directional
  - 14,000 uni-directional
Additional Features

- Environmental Chamber (Radiant heater)
  - 50 mm styrofoam with aluminum siding
  - Most tests are conducted at a controlled temperature
- Single or dual tire
- Laser profiling system
Pavement Profile Measurements

In most APT experiments:

- Characterizing test pavement surface
- Measurement of permanent deformation
- Accurate mapping of cracks
Measurement of Rut Depth

- **Manual Methods**
  - Straight edge

- **Automated Methods**
  - Non contact profilers
  - Various proprietary devices

![Diagram](image-url)
Manual Rut Measurements

- **Advantages**
  - Widely accepted as base-line measurements
  - Very easy to perform

- **Disadvantages**
  - Time consuming and labor intensive
  - Limited data points, therefore difficult to obtain entire test surface profile
  - More chances of measurement error
Automated Rut Measurements

- FDOT Laser Profiling System
  - Fully automated
  - Entire surface profile is obtained
  - One set of profiles is taken in less than 10 minutes
  - Highly accurate
  - Does not tie up personnel
Laser Profiling System

- Two 16 kHz Lasers, mounted 762mm (30 in) apart
- Very accurate
- Wheel carriage travels at 4 kph during data collection
- Carriage is ‘unloaded’
Pavement Profiles

Data collection:
Wheel unloaded
Profile time = 10 minutes

25mm (1 in) Test Section
Data Collection

- 2 sets of data are acquired, one from each laser
- Data is averaged every 100 mm in the longitudinal direction
- Results in a 58 x 134 data array
- Data saved in ASCII format
Data Acquisition

- Left Laser
- Overlap
- Right Laser
- Test Section

58 data points
134 data points
Data Analysis

Important Considerations

- Ensure data collection procedure and data format are standardized
- Collection of initial or ‘untested’ pavement surface profile is essential
- Algorithm for data processing
- Overlapping data is very important
FDOT’s Rut Analysis Program

- Developed in-house
- MS-Excel, Visual Basic for Applications (VBA) based
- Very easy to use
- Complies, analyzes and stores data
Program Flow Chart
Typical Transverse Profile

Transverse Distance (mm)

Height (mm)

Initial $\rightarrow$ 100 Passes $\rightarrow$ 500 Passes $\rightarrow$ 1,000 Passes $\rightarrow$ 5,000 Passes $\rightarrow$ 10,000 Passes $\rightarrow$ 25,000 Passes $\rightarrow$ 50,000 Passes $\rightarrow$ 80,000 Passes $\rightarrow$ 130,000 Passes
Calculation of Rut Depth

Virtual Straight Edge

Rut Depth = 7.4mm
Rut Depth = 6.9mm
Rut Depth = 8.4mm
Longitudinal Variation of Rut Depth

![Graph showing the longitudinal variation of rut depth along the test lane. The y-axis represents rut depth in millimeters, ranging from 0 to 2.5. The x-axis represents longitudinal distance along the test lane in millimeters, ranging from 0 to 6000. The graph indicates a variable rut depth profile with peaks and troughs, particularly noticeable around the 2500 and 3500 mm marks.]
Rut Measurements

Average Rut Depth (mm) vs. Number of HVS Passes

- Both Lifts Unmodified
- Top Lift Modified, Bottom Lift Unmodified
- Both Lifts Modified

0 50,000 100,000 150,000 200,000 250,000 300,000

Rut Measurements
Laser Based Profiling System

Other Applications
Flexible Pavements – Rut Development
Rigid Pavements – Slab Curling
Raised Pavement Markers
FDOT’s Experience

- Laser Based Profiling System
  - Extremely beneficial
  - Large savings in time and manpower resources
  - Entire surface profile is obtained
  - Data can be used for other analyses – Volume change analysis.
Presentation

- Rut Initiation Mechanisms In Asphalt Mixtures as Generated Under APT Loading
  - Recent and Significant Accelerated Pavement Testing Results, Session 708
  - Wednesday, January 12, 4.30 – 6.00pm
  - Shoreham
Questions?