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Project Summary Report 0-1782-S
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Project 0-1782: Development of a Real-Time Transverse Pavement Profile Measurement System

Author: Roger S. Walker, Ph.D., P.E.

PROJECT SUMMARY REPORT

Development of a Real-Time Transverse Pavement Profile Measurement System: Summary Report

The Texas Department of Transportation (TxDOT) has been using a five-sensor rut bar system that uses measurements made with ultrasonic sensor technology to automatically collect pavement rutting for Pavement Management Information System (PMIS) purposes. A number of problems have occurred while using the acoustic sensors for these measurements.

This report discusses the results from Project 0-1782 between the Texas Department of Transportation and The University of Texas at Arlington, titled "Development of a Real-Time Transverse Pavement Profile Measurement System." The project was initiated to investigate the uses of scanning laser technology for measurement of rut that would alleviate some of the problems and limitations of the acoustic sensor systems.

What We Did...

To determine if a scanning laser system could improve TxDOT rut measurement activities, an investigation of different scanning laser systems was conducted. Two scanning laser systems were found that were suitable for the project objectives. The first laser system, sold by Phoenix Scientific, was much too costly, and the availability was questionable at the time of the project. The second laser system was a low-cost scanning laser system manufactured by Acuity, Inc.

During the project a functional system was developed using the Acuity AccuRange AR4000-LIR laser system to scan the full width of the paving lane. The project developed software and procedures to report and store the rut measurements computed from the displacement readings. A number of unexpected problems in processing the raw laser readings had to be addressed during the investigation.

The main problems were distortions in the signal because of noise that occurs as the laser beam is swept across the pavement surface. When scanning the laser beam across a pavement or other non-smooth surface, noise spikes much greater than the profile signal would occur. Thus much of the project research effort was focused on developing a means to distinguish the signal from the noise and to address methods with which rut measurements processing could be done at highway speeds.

The Acuity laser includes a line scanner and a high-speed interface module. A host machine personal computer (PC) is used to read and process the raw laser data. The AR4000-LIR laser is a modulated beam-type system that uses a range-to-frequency conversion method to determine displacements. The laser control module uses a microprocessor for controlling the operation of the laser and acquisition of the measurements. The line scanner uses a rotating scanning mirror and encoder, driven by a direct current (DC) motor. The high-speed interface module is used to digitize the raw uncalibrated values from the laser and to send these readings to the PC via the PC104 or PCI bus. Software in the scanner program on the host PC is used to adjust the range readings in accordance with a predetermined calibration table for the particular AR4000-LIR unit.

What We Found...

A number of data collection tests were performed to determine the capabilities of the system. TxDOT and project personnel devised a mounting procedure so the system could be placed on the back of the vehicle for high-speed measurements. Once all of the initial data acquisition and processing procedures were ready, the scanner was taken to a number of locations for field tests. These tests were instrumental in developing the processing methods for reducing noise and developing the rut measurement process. Analysis efforts were required to discern usable signals from the operational noise. Laboratory and field tests were designed to verify the data processing and analysis software and methods. The results aided the further refinement of the analysis software.

Figure 1 illustrates the laser scanning system (laser and housing shown on the back of the vehicle) being used at the Texas Transportation Institute (TTI) ride-rut facility at the Texas A&M Riverside Campus. Tests were also made on road sections in south Texas and around Austin.

In order to quantify and compare readings from the scanning laser with known rut conditions, a series of tests were conducted in May of 2002. These tests included provisions for both stationary (static) and moving (dynamic) measurements. The tests were conducted at a site on FM 971 near Granger, Texas, for comparing the stationary and high-speed rut measurements with each other and to compare the scanning laser results with results from other rut measuring devices. The other devices used were the dip stick, straight edge, and Texas Modular Vehicle (TMV) profiler. Additionally, rut readings were collected using the TxDOT laser and acoustic rut systems.

For the static tests, readings from stationary scans of the scanning laser, the dip stick, the TMV profiler, and the straight edge were used to find the maximum and average maximum rut in both the right and left wheel paths. For the dynamic tests, rut

Figure 1. Scanner on Vehicle at the TTI Ride-Rut Facility.

measurements were made with the TxDOT laser and acoustic rut measurement systems.

These measurements were all compared to those obtained from the scanning laser rut reports. The tests were conducted on the eastbound lane of FM 971 approximately 2 miles west of Granger. In Figure 2 the dip stick (foreground) and TMV profiler (background) are shown during measurements on one of the Granger sections.

For the tests near Granger, the scanning laser processing procedures were used on the raw scanned data to compute rut for both the left and right wheel paths. To compare these readings with the other devices, the string line algorithm (used in the scanning laser rut measurement procedures) was applied to the set of profile points from both the TMV and dip stick. Figure 3 illustrates repeat rut measurements at 30 and 60 mph made every 0.01 mile by the Scanning Laser Rut Measurement System over all four test sites.

Figure 2. Dip Stick and TMV Profiler in Use at a Test Section near Granger, Texas.

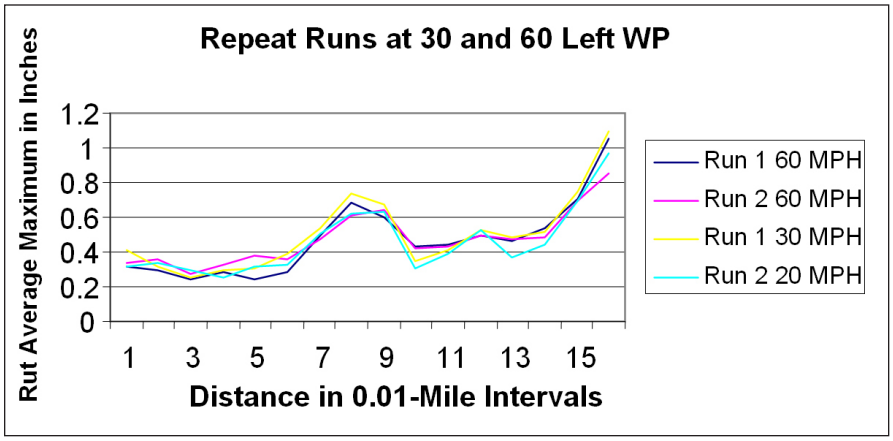

Figure 3. Plots of Left Wheel Path (WP) Rut Measurements Using Scanning Laser System.

The Researchers Recommend...

The project provided a prototype scanning laser system for rut measurements and a project report for implementation. A string line algorithm applied to the transverse profile measurements provides a means to quantify rut. The accuracy of the system for measuring rut is not only a function of the laser, but is also directly related to the length of the scan, the rotational speed of the scanning mirror, and the smoothing of the scanning laser data.

The scanning laser system is ready for implementation at the project level. Additional studies, however, are needed to monitor its usage and/or modify the rut calculation and noise reduction procedures. Further studies could also be performed to consider usage of the system for other applications, such as estimating cut and fill design requirements for new pavements or improving maintenance on existing pavements.

For More Details...

The research is documented in Report 0-1782-1, *Development of a Real-Time Transverse Pavement Profile Measurement System*.

Research Supervisor: Dr. Roger Walker, P.E., The University of Texas at Arlington, walker@cse.uta.edu, (817) 272-3640

TxDOT Project Director: Carl Bertrand (retired), Construction Division

TxDOT Research Engineer: German Claros, P.E., Research and Technology Implementation Office, gclaros@dot.state.tx.us, (512) 465-7403

To obtain copies of reports, contact Dr. Roger Walker, The University of Texas at Arlington, walker@cse.uta.edu, (817) 272-3640.

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Texas Transportation Institute/TTI Communications
The Texas A&M University System
3135 TAMU
College Station, TX 77843-3135