Summary of Final Report, Contract DO-51684 (DO-2022)
July 2005

MEASURING PAVEMENT FRICTION CHARACTERISTICS AT VARIABLE SPEEDS FOR ADDED SAFETY

PROBLEM STATEMENT

The Florida Department of Transportation (FDOT) has conducted standard friction tests on state roadways since 1958. The first Pavement Friction Testing Unit, meeting the requirements of ASTM Committee E-17 on Vehicle-Pavement Systems was fabricated for the Department in 1966. FDOT currently owns and operates four modern Pavement Friction Testing Units. Each of these units consists of a tow vehicle, water tank, friction trailer, and mobile data processor. Friction measurements are obtained from the force induced on a locked test wheel as it is dragged over a wetted pavement surface. The mean Friction Number (FN) of the pavement surface is obtained from this test. All pavement friction testing currently performed by FDOT is conducted in accordance with the provisions outlined in ASTM E 274, "Standard Test Method for Skid Resistance of Paved Surfaces Using a Full-Scale Tire." Testing is typically performed at the specified speed of 40 mph (64.4 km/h), using the standard "Ribbed Tire" as specified by ASTM E 501, "Specification for Standard Rib Tire for Pavement Skid-Resistance Tests."

Although the current FDOT friction testing program is fully implemented, several issues need to be addressed, especially safety concerns while conducting the test (i.e., potential conflicts with the motoring public on high-speed facilities, ramps, and at other potentially hazardous sites). The current specified test speed of 40 mph (64.4 km/h) is used on all state roadways, including primary, secondary, interstate, and toll roads. To maximize safety and minimize traffic disruption, friction testing is typically conducted on weekdays and sometimes at night. Height-sensor based (non-contact) technology may accommodate variable testing speeds, comparable to the speed limits of the facilities being tested.

OBJECTIVES

The objective of this study was to evaluate the feasibility of enhancing the existing FDOT friction-testing program through the use of non-contact, laser-based sensors. Researchers evaluated a LMI Technologies, Selcom, Optiocator 64 kHz laser system installed on a selected FDOT Pavement Friction Testing Unit.

FINDINGS AND CONCLUSIONS

Five FDOT calibration sections, located in the vicinity of the State Materials Research Park in Gainesville were tested as part of this initial study. These five calibration sections represent a wide range of surface textures, including both dense-graded and open-graded friction courses common to Florida state roadways. Each of these calibration sections is further divided into five sub-sections.

The tests conducted on each sub-section of each calibration section included (1) friction testing in accordance with ASTM E 274, using both the standard ribbed tire, as described in ASTM E 501, and the smooth tire, as described in ASTM E 524; (2) non-contact, macrotexture measurement, using the 64 kHz laser system installed on the FDOT Pavement Friction Testing Unit, in accordance with ASTM E 1845; and (3) volumetric macrotexture measurement in accordance with ASTM E 965, "Standard Test Method for Measuring Pavement Macrotexture Depth Using a Volumetric Technique," more commonly referred to in practice as the "Sand Patch" test.

Researchers plotted the Mean Profile Depth (MPD), as obtained from the 64 kHz laser, against the Mean Texture Depth (MTD), as obtained from the Sand Patch test. Overlapping 95% Confidence Interval bars for the MPD obtained at different test speeds illustrate that test speed does not significantly affect the 64 kHz measure of texture between 20 and 60 mph. In other words, at a 95% level of confidence, the MPD measured for a given calibration section is statistically the same at 20, 40, and 60 mph (32.2, 64.4, and 96.6 km/h). The MPD, as measured with the 64 kHz laser, is highly repeatable at variable speeds.

If the results of the sand patch test (MTD) are the correct measure of texture, then the 64 khz laser does not provide an accurate measure of this parameter.. This discrepancy is recognized in ASTM E 1845 by way of a linear transformation equation. Thus, it should not be surprising that we observe a difference in sand patch data and laser texture data.

The research presents correlations for Friction Number at 40 mph (64.4 km/h) versus Friction Number at 20 and 60 mph (32.2 and 96.6 km/h). Researchers found that Friction Number varies with changes in test speed, and that there is a strong linear correlation between FN40R and FN60R. However, based on the data obtained from the calibration sections tested in this study, the best relationship between FN40R and FN20R appears to be polynomial.

The research also provides correlations between FN40R and FN40S. The R2 value for the correlation between tests conducted using the standard ribbed tire and the smooth tire are relatively strong. However, an even stronger correlation is exhibited for the non-linear, polynomial relationship.

Finally, the observed correlations between MPD and FN40R and MPD and FN40S are presented. These relationships between MPD and FN are extremely weak. This observation is not surprising when considering that pavement texture is only one component of friction. This multi-component concept is clearly recognized with the International Friction Index (IFI) parameters of F60 and Sp, which provide standardized measures of both texture and friction. Although it is tempting to seek a simple empirical method to estimate pavement friction, the data documented in this study clearly illustrates that macro-texture is a poor predictor of overall pavement friction.

The data collected in this study were ultimately used to demonstrate the calculation of the IFI parameters of F60 and Sp. The results of this demonstration illustrate that the IFI parameter, F60, as estimated from the standard ribbed tire in accordance with ASTM E 501, is not in close agreement with that estimated from the smooth tire, as described in ASTM E 524. Presumably, if the calibration constants used in the transformation of Friction Numbers to this parameter were correct, the F60 values would be in agreement. Thus, this study confirms that FDOT must develop in-house calibration/harmonization constants as described in ASTM E 1960 in order to fully implement IFI as a standardized measure of pavement friction.

BENEFITS

The results of this study demonstrate that the 64 kHz non-contact, macrotexture measurement system described herein provides a repeatable and accurate measure of MPD. With a repeatable measure of MPD and wet friction, IFI can be reported in accordance with ASTM E 1960. The research provides an example of how FN40 data (as obtained from ASTM E 274) and MPD (as obtained from the 64 kHz non-contact, macrotexture measurement system) can be transformed for IFI reporting. The results of this study, when fully implemented, will yield a safer, faster, and more appropriate method of estimating pavement friction characteristics on high-speed facilities, ramps, and other potentially hazardous sites in Florida.

This research was conducted by N. Mike Jackson, Ph.D., P.E., of the University of North Florida. For more information, contact Charles.Holzschuher, Project Manager, at (352) 955-6341, charles.holzschuher@dot.state.fl.us.